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Jan 24/73

SURVEY

OF THE

Wisdom of GOD in the CREATION:

OR A

COMPENDIUM

OF

Natural Philosophy.

IN THREE VOLUMES.

(John Worboys)

THE SECOND EDITION

VOL. I.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wondrous fair! Thyself how wondrous then!

MILTON.

BRISTOL:

Printed by WILLIAM PINE, 1770.

S U R V E Y

OF THE
HISTORY OF GOD IN CREATION

C O M P E N D I U M



Natural Philosophy

IN THREE VOLUMES.

THE SECOND EDITION.

Printed and sold by W. Wood, at the
Museum, in Pall Mall.
London.



Printed by WILLIAM PINE,
BRISTOL.



P R E F A C E.

1. I HAVE long desired to see such a *Compendium of Natural Philosophy*, as was, 1. Not too diffuse, not expressed in many Words, but comprized in so moderate a Compass, as not to require any large Expence, either of Time or Money: 2. Not maimed or imperfect, but containing the Heads of whatever (after all our Discoveries) is known with any Degree of Certainty, either with regard to the Earth or Heavens. And this I wanted to see, 3. In the plainest Dress, simply and nakedly exprest, in the most clear, easy and intelligible Manner, that the Nature of the Things would allow: Particularly free from all the Jargon of *Mathematics*, which is mere *Heathen Greek* to common Readers. At the same Time I wished to see this short, full, plain Account of the visible Creation, directed to its right End: Not barely to entertain an idle, barren Curiosity, but to display the *invisible Things of God*, his Power, Wisdom and Goodness.

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2. But

2. But I cannot find such a Treatise as this in any Modern, any more than Antient Language. And I am certain, there is none such in the *English* Tongue. What comes nearest to it of any Thing I have seen, is Mr. Ray's *Wisdom of God in the Creation*, Mr. Derham's *Physic* and *Astro-Theology*, Nieuwentyt's *Religious Philosopher*, Maiber's *Christian Philosopher*, and *Nature delineated*. But none of these, single, answers the Design. And who will be at the Pains, to extract the Substance of them all, and to add the later Discoveries, of which they had little Knowledge, and therefore could take but little notice? This is a *Desideratum* still; and one that a Lover of Mankind would rejoice to see even tolerably supplied.

3. I am thoroughly sensible, there are many who have far more Ability, as well as Leisure, for such a Work than me. But as none of them undertakes it, I have myself made some little Attempt in the ensuing Volumes. Herein following Mr. Derham's Plan, I divide the Work into *Text* and *Notes*. The Text is in great Measure translated from the *Latin* Work of John Francis Buddaeus, the late celebrated Professor of Philosophy, in the University of *Jena*, in *Germany*. But I have found Occasion to retrench, enlarge or alter every Chapter, and almost every Section. So that it is now, I believe, not only *pure*, containing nothing false or uncertain; but as *full* as any Tract can be expected to be, which is comprized in so narrow a Compass; and likewise *plain*, clear and intelligible to one of a tolerable Understanding. The Notes contain the Sum of what is most valuable, in the above-named Writers: To which are added the choicest Discoveries both of our own, and of the Foreign Societies; chiefly extracted from that great Treasury of Learning, Mr. Chambers's *Dictionary*. These

These likewise, I trust, are as plain and clear, as the Nature of the Things spoken will allow : Altho' some of them, I know, will not be understood, by an unlearned or inattentive Reader.

4. Meantime I must apprize the Reader, that I have sometimes a little digressed, by reciting both uncommon Appearances of Nature, and uncommon Instances of Art : And yet this is not properly a Digression, from the main Design I have in View. For surely in these Appearances also, the Wisdom of God is displayed : Even that manifold Wisdom, which is able to answer the same Ends by so various Means. And those surprizing Instances of Art, do likewise reflect Glory upon Him, whose Spirit in Man gives that Wisdom, whose Inspiration teacheth Understanding.

5. It will be easily observed, that I endeavour throughout, not to account for Things, but only to describe them. I undertake barely to set down what appears in Nature, not the Cause of those Appearances. The Facts lie within the Reach of our Senses and Understanding ; the Causes are more remote. The Things are so, we know with certainty : But why they are so, we know not. In many Cases we cannot know ; and the more we inquire, the more we are perplexed and intangled. God hath so done his Works, that we may admire and adore : But we cannot search them out to Perfection.

6. And does not this open to us another Prospect ? Altho' one we do not care to dwell upon. Does not the same Survey of the Creation, which shews us the Wisdom of God, shew the astonishing Ignorance and Short-sightedness of Man ? For when we have finished our Survey, what do we know ? How inconceivably little ? Is not every thinking Man constrained to cry out, And is this

All? Do all the boasted Discoveries of so enlightened an Age, amount to no more than This? *Vain Man would be wise!* Would know all Things! But with how little Success does he attempt it? How small a Part do we know even of the Things that encompass us on every Side? I mean, as to the very *Fact*: For as to the *Reasons* of almost every Thing which we see, hear or feel, after all our Researches and Disquisitions, they are hid in impenetrable Darkness.

7. I trust therefore the following Tract may, in some Degree, answer both these important Purposes. It may be a Means, on the one Hand, of humbling the Pride of Man, by shewing that he is surrounded on every Side, with Things which he can no more account for, than for Immensity or Eternity: And it may serve, on the other, to display the amazing Power, Wisdom and Goodness of the great Creator; to warm our Hearts, and to fill our Mouths with Wonder, Love and Praise.

John Wesley.





Wisdom of GOD in the CREATION:

OR A

COMPENDIUM OF

Natural Philosophy.

The INTRODUCTION.

Of the gradual Improvement of Natural Philosophy.

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| <p>1. The Order observed in this Treatise:</p> <p>2. The Method of philosophizing among the Hebrews and Egyptians:</p> <p>3. Among the Greeks: The Philosophy of Pythagoras, Plato, Aristotle:</p> | <p>4. The different Method pursued by the four Greek Sects:</p> <p>5. The Philosophy of the Schoolmen:</p> <p>6. The Revival of Philosophy by Lord Bacon:</p> <p>7. Greatly promoted by Philosophical Societies:</p> <p>8. The</p> |
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8. *The Improvement made in every Branch of it: In Anatomy, the Discovery of the Circulation of the Blood, of the Lacteal Veins, and the Thoracic Duct:*

9. *Of the Generation of all Animals from Eggs:*

10. *Of the Transfusion of Blood:*

11. *Diseases themselves and the Operations of Medicines give Occasion for farther Discoveries:*

12. *Many Anatomical Discoveries have been made by Microscopes:*

13. *Many, with regard to Brutes, particularly Fishes and Insects:*

14. *Many likewise, with regard to Plants, Stones, Metals and Minerals:*

15. *Great Improvements from the Art of Chemistry:*

16. *Discoveries concerning the Loadstone:*

17. *Concerning Glass and Burning-Glasses:*

18. *The Nature of the Air is more accurately discovered, by Means of the Barometer, the Thermometer and the Air-Pump:*

19. *Discoveries relating to Water:*

20. *Discoveries which shew the Nature of Fire: Of Gunpowder, Phosphorus, Aurum Fulminans:*

21. *Of the Earth, and the chief Systems of the Universe:*

22. *Of the Sun, the Planets and their Satellites:*

23. *Of the causes of Natural Bodies:*

24. *Of Spirits and Divine Things.*

1. **N***NATURAL Philosophy treats both of God Himself, and of his Creatures, visible and invisible. Of these I purpose to speak in such a Manner, as to ascend from the Consideration of Man, thro' all the Orders of Things, as they are farther and farther removed from us, to God the Center of all Knowledge. (I mean, of visible Things: Of the invisible World we cannot know much, while we dwell in Houses of Clay.) Thus Speculative Philosophy ascends from Man to God, Practical descends from God to Man.*

2. *The most ancient Nations, the Egyptians and Hebrews in particular, philosophized much concerning God, and concerning Genii, good or evil Spirits, of an Order superior to Man. What they taught concerning*



cerning the visible World, related chiefly to its Origin, the Changes it was to undergo, and its final Dissolution. But on all these Heads they only delivered to their Posterity, what they had received from their Forefathers.

3. Among the *Greeks*, *Thales*, *Milestus*, and his Followers, applied themselves, with great Industry, to discover, with the best Helps they had, the material Causes of natural Things. They were succeeded by others, who more curiously searched into the Structure of Natural Bodies. Here the Foundation of Natural History was laid, in various Observations on Plants, Animals and other Things. And herein the Endeavours of *Aristotle* and *Theophrastus* in particular are to be commended. Yet in other Respects, *Aristotle* did not promote, but rather obstruct the Knowledge of Nature: For he made Philosophy as unintelligible by his abstract and metaphysical Notions, as *Plato*, *Pythagoras* and others did, by their Ideas, Numbers and Symbols.

4. In succeeding Times, when the four *Greek* Sects, the *Platonic*, *Peripatetic*, *Epicurean* and *Stoic* divided the World between them, the *Platonists* almost confined themselves and their Opinions to the Subject of Divinity; the *Peripatetics* regarded little but Logic; the *Stoics* little but Moral Philosophy; and the *Epicureans* had small Concern about any, being immersed in sensual Pleasures: So that none of them made any considerable Improvement in any Branch of Natural Philosophy.

5. When the utter Barbarism which followed was a little dispelled, *Aristotle* began to reign. His Followers (the *School-men*, as they were called) might have improved Natural Philosophy, if (like their Master, they had diligently cultivated the Knowledge of Nature, and searched out the Properties of particular Things: But it was their Misfortune, to neglect what was commendable in him, and to follow only what was blame-worthy; so as to obscure and pollute all Philosophy, with abstract, idle, vain Speculations. Yet some of them, after the *Arabians* had introduced the Knowledge of Chemistry into *Europe*, were wise

above

above the Age they lived in; and penetrated so far into the secret Recesses of Nature, as scarce to escape the Suspicion of Magic. Such were *Roger Bacon* and *Albertus Magnus*.

6. After the Revival of Learning, as all other Branches of Philosophy, so this in particular received new Light. And none was more serviceable herein than *Lord Bacon*; who well understanding the Defects of the School-Philosophy, incited all Lovers of Natural Philosophy, to a diligent Search into Natural History. And he himself led them the way, by many Experiments and Observations.

7. After this, not single Persons only, but whole Societies applied themselves carefully to make Experiments; that having accurately observed the Structure and Properties of each Body, they might the more safely judge of its Nature. And the Advantages which have arisen from hence manifestly appear from the Memoirs of the Royal Society at *London*, of the Academy of Sciences at *Paris*, and those of the same kind in *Germany*, as well as several other Parts of *Europe*.

8. To mention but a few of the late Discoveries in each Branch of Natural Philosophy. With regard to the Structure of an Human Body, how many Things have modern Anatomists discovered, which were either little understood by the Antients, or wholly unknown to them? Such for instance, is the Circulation of the Blood, discovered by *Dr. William Harvey*, whose "Anatomical Exercitations" concerning it were first published in the Year 1628. Such were the Lacteal Veins, discovered first in Brutes by *Caspar Asellius*, of *Cremona*; and soon after in Men: Such the Thoracic Duct, and Receptacle of the Chyle, observed first by *Dr. John Pecquet*, of *Paris*, whereby the whole Course of the Blood is now clearly understood.

9. *Dr. Harvey* improved Natural Philosophy, by another no less eminent Discovery: For he was the first of the Moderns that shewed all Animals to be generated from Eggs. That the Antients knew and taught this, (*Orpheus* in particular) cannot reasonably be doubted. But as the Knowledge of it was intirely lost,

lost, to revive was the same Thing as to invent it. It is obvious, how great a Light this pours upon that dark Subject, with regard to the Generation of Men, as well as of other Animals.

10. Another remarkable Discovery in the last Century, was that of the Transfusion of Blood. The Blood of a young, lively, healthy Animal was transfused, by Means of a small, silver Tube properly adjusted, into the Veins of another, which was old, weak and sickly. And the Effect has amazed all the Beholders. When the Experiment was tried before several of the Royal Society, a feeble, worn-out Dog, ready to die with Age, and hardly able to trail his Legs after him, was no sooner filled with young Blood, than he leaped up, as from Sleep, shook himself, and ran up and down, as lively and active as a Puppy. In *France* the Experiment has been made upon Men, and with as surprizing Success. What Pity, that so important an Experiment should ever fall into disuse! That it is not still repeated upon proper Occasions? Especially where all other Means fail.

11. It cannot be denied, that *Physicians* have signally improved this Branch of Philosophy, as they have continual Opportunities of making new Discoveries in the Human Body. In Diseases themselves, the wonderful Wisdom of the Author of Nature appears: And by means of them many hidden Recesses of the Human Frame are unexpectedly discovered. The Powers of Medicines also variously exerting themselves, lay open many Secrets of Nature.

12. And how many Things in all Bodies, as well as in the Human, which eluded all the Art and Industry of the Antients, have the Moderns discovered by the Help of *Microscopes*? Altho' these are not properly a modern Invention: It being certain, something of this kind was in use, many hundred Years ago. There are several Works of great Antiquity still extant, the Beauties of which cannot even be discerned, much less could they have been wrought, by the finest naked Eye, which ever was in the World. Such is that Seal, now in the Cabinet of the King of *France*, allowed to be

be at least fifteen hundred Years old, Six-tenths of an Inch long, and four broad, which to the naked Eye presents only a confused Groupe, but surveyed with a Microscope, distinctly exhibits Trees, a River, a Boat, and sixteen or seventeen Persons.

13. Now whatever assists us in searching out the Structure of an Human Body, equally helps us to find out the Nature and Properties of other Animals. Hence in these likewise we have received great light, from Anatomical and Microscopical Observations. Those especially who have bestowed their whole Time and Thoughts on one kind of Animals, (as Dr. *Willoughby*, on Fishes, Dr. *Swammerdam*, of *Amsterdam*, on Insects) have illustrated to a surprizing degree, the Subjects on which they wrote.

14. Many have diligently searched into the Nature of Plants; particularly Mr. *Ray*, who has not only ranged them in a new Method, but also wrote an elaborate History of them. Others have described with equal Diligence either Plants in general, or those of a particular Country. And others have shewn the like Industry in finding out and explaining the Nature of Stones, Metals, Minerals, and other Fossils.

15. Nor is it strange that the Moderns have penetrated farther into the Recesses of Nature than the Antients, considering the Advantages they have received, from the Art of *Chemistry*. Not that this is an Invention of later Ages: It was in some measure known long ago. But as this Art has been cultivated in our Age, with far greater Accuracy than ever, so by this means many Properties of Natural Bodies have been discovered; of Fossils in particular.

16. But none of these have so much engaged the Study of the Learned, or so well deserved it, as the *Lodestone*. Its attractive Force was known to the Antients, and the Origin of that Discovery is recorded by *Pliny*. But it does not appear that they knew of its pointing to the Pole, or of the Use of the Compass. This (the Compass) was invented by *John Gata*, in the Year 1300. But it has been since observed, that the magnetic Needle seldom points exactly to the Pole,

but

but varies from it some Degrees to the East or West, in a fixt and regular Order.

17. Nearly related to the Nature of Fossils is *Glass*, which was well known to the Antients, being mentioned by *Plutarch* and *Lucian* among the *Greeks*, by *Lucretius*, *Pliny* and others among the *Latins*. Yet the Art of making Glass has been since their Times abundantly improved. One Branch of this is, the Art of making Burning-Glasses, which are now brought to so great Perfection, as either to melt or reduce to ashes the most solid Bodies, in a very few Moments. If these were known to the Antients at all, (which may reasonably be doubted) yet the Art was wholly lost for many Ages, and not recovered till of late Years.

18. Later Ages have likewise made many Discoveries, with regard to Earth, Water, Fire and Air: The last of which, Air, tho' it be of so fine a Texture as to be wholly invifible, yet producing such amazing Effects, has excited the most diligent Enquiries of the Curious. Nor does any Part of Philosophy afford a wider field for Experiments and Discoveries. The Weight of it we can ascertain by that curious Instrument, the *Barometer*, invented by *Torricellius*, the Degrees of Heat and Cold, by the *Thermometer*. By the Air-pump (invented by *Otto Guericke*, Mayor of *Magdeburgh*) the Air is drawn out of any Bodies, or more largely thrown into them. And hereby many Effects are produced, which deserve our diligent Consideration.

19. With regard to *Water*, the Discoveries of later Times are numerous and important. Such are the Diving-Bell, invented by *George Sinclair*; the Diving-Machine of *Alphonso Borelli*, a kind of Boat, which is so contrived as to be navigated under Water: And the Art of making Salt-water fresh, which is now done with little Expence, so far that the Saltness is taken away, and it is fit for almost all Uses.

20. The Nature and Properties of *Fire* also have been accurately traced in late Ages: For which new Occasion was given by the Invention of *Gunpowder*, by

Berthold Schwartz, in the fourteenth Century. *Aurum Fulminans*, a yet later Invention, goes off with a louder Explosion than Gunpowder. Other Bodies there are, which do not burn, and yet emit Light. Such is the *Bononian Stone*, which placed in the dark, diffuses Light like a burning Coal. It is well known that the Preparation called *Phosphorus*, has the same Property.

21. Various Theories of the *Earth* have lately appeared. But they are no more than ingenious Conjectures. The same may be said of the Systems of the Universe, a few Particulars excepted. The *Ptolemaic* System, which supposes the *Earth* to be the Centre of the Universe, is now deservedly exploded: Since *Copernicus* has revived that of *Pythagoras*, which was probably received by most of the Antients. *Tycho Brahe's*, which jumbles both together, is too complex and intricate, and contrary to that beautiful Simplicity, conspicuous in all the Works of Nature.

22. The Telescope however (invented by *Galileo*) has discovered many Stars unknown to the Antients, together with the Nature and Motion of the Planets, both Primary and Secondary. By this also have been discovered the Spots on the Sun, the Inequality of the Surface of the Moon, the Nature of the Galaxy or Milky-Way, and many other Particulars relating to the Heavens.

23. With regard to *Body* in general, it is commonly supposed, that our Age has a vast Advantage over Antiquity, by having found out new Principles and Hypotheses, whereby we can account for all the Secrets of Nature. But this will bear a Dispute. For beside that the chief of our Hypotheses are not new, but known long ago, the Learned have hitherto very little profited by all their Hypotheses. And in Truth all their Disquisitions touching the Causes of Natural Bodies, terminate in mere Conjectures: One whereof is often more probable than another, but none admits of any solid Proof.

24. What remains of Natural Philosophy, is, The Doctrine concerning God and Spirits. But in the tracing of this, we can neither depend upon Reason

nor Experiment. Whatsoever Men know, or can know concerning them, must be drawn from the Oracles of God. Here therefore we are to look for no new Improvements, but to stand in the good old Paths: To content ourselves with what God has been pleased to reveal; with the Faith once delivered to the Saints.





Part First,
Of Man.

C H A P. I.

Of the Structure of the Human Body.

- | | |
|-------------------------------------|--------------------------------------|
| 1. <i>The Similar, solid Parts,</i> | 16. <i>The Dissimilar Parts,</i> |
| 2. <i>A Fibre,</i> | <i>in particular the Head, Cere-</i> |
| 3. <i>A Bone,</i> | <i>brum, Cerebellum, Medulla,</i> |
| 4. <i>A Cartilage,</i> | <i>oblongata,</i> |
| 5. <i>A Membrane,</i> | 17. <i>The Meninges,</i> |
| 6. <i>An Artery,</i> | 18. <i>The Brain,</i> |
| 7. <i>A Vein,</i> | 19. <i>The Origin of the</i> |
| 8. <i>The Lymphatic Vessels,</i> | <i>Nerves,</i> |
| 9. <i>A Nerve,</i> | 20. <i>The Pineal Gland,</i> |
| 10. <i>The Flesh,</i> | 21. <i>The Guards of the Eye,</i> |
| 11. <i>A Gland,</i> | 22. <i>The Muscles of the Eye,</i> |
| 12. <i>A Muscle,</i> | <i>Tunica Adnata,</i> |
| 13. <i>The Cuticula and Skin,</i> | <i>Structure of the Eye,</i> |
| 14. <i>The Fat,</i> | 23. <i>The Coats of the Eye,</i> |
| 15. <i>The Panniculus Carnosus,</i> | 24. <i>The Humours of the Eye,</i> |

25. *The*

25. *The External Parts of the Ear; the Internal, particularly, the Drum,*

26. *The Bones, Passages, Windows, Labyrinth,*

27. *The Nostrils,*

28. *The Tongue, and Teeth,*

29. *The Palate,*

30. *The Uvula and Tonsils,*

31. *The Hair,*

32. *The Heart,*

33. *The Pericardium,*

34. *The Lungs,*

35. *The Thorax, Intercoastal Muscles, Diaphragm,*

36. *The Pleura & Mediastinum,*

37. *The External Parts of the Middle Cavity,*

38. *The Stomach,*

39. *The Intestines and Mesentery.*

40. *The Lacteal Veins,*

41. *The Omentum, Peritoneum, Pancreas,*

42. *The Liver,*

43. *The Gall-Bladder, Ducts, Spleen,*

44. *The Kidneys, Ureters, Bladder,*

45. *The Hands,*

46. *The Feet,*

47. *The Animal Spirits,*

48. *The Secretion of the other Fluids,*

49. *The Blood,*

50. *What are the first Elements of the Body?*

1. **A**S Man ought to know himself best, we begin our Treatise here. And first, let us contemplate the Human Body. The Parts of this are either *solid* or *fluid*. Those of the Solid, of which the rest are formed, are termed *Similar Parts*. Such are Fibres, Bones, Membranes, Ligaments, Arteries, Veins, Lymphatic Vessels, Nerves, Flesh, Muscles, Tendons: And those General Coverings of the Body, the Cuticle, the Skin, Fat, and the Panniculus Carnosus.

2. A *Fibre* is a kind of slender Thread, of which all the other Parts of the Body are woven: According to the Difference of which, the Substance of the Fibres is different also.

3. The hardest Part of the Body, white and void of Sense, is termed a *Bone*. The Bones are covered with a thin Skin, called the *Periosteum*, extremely sensible. *

B 3

4. Annex

* The Bones consist of thin Plates, lying one upon another; and these again, of Fibres running Lengthways, some to the Extremity of the Bone, some not so far. Yet none of them termina

4. Annexed to the Bones are the *Cartilages*, white, flexible and smooth; most of which in process of Time become Bones, hard and quite void of Sense.

5. The

there, but are continued transversely, and as it were arched, the Fibres of one Side meeting and uniting with those of the other, and this at each Extremity.

These Plates are differently disposed in different Bones: In those that have a large Cavity, they are contiguous on each Side, and very closely united. In those whose Cavities are small, many of the inner Plates are distant from each other, having little long Cells between them. In Bones whose Plates are contiguous, there are Pores thro' and between them, (beside those for the Blood-Vessels.) The first pierce them transversely, from the Cavity to the external Surface of each Plate. The second run Lengthways between the Plates, and diffuse an Oil with which they are supplied by the transverse Pores.

The Bones are generally bigger at each End than in the Middle, that the Joints may be firm, and the Bones not so easily dislocated. But to strengthen the Middle of the Bone, the Fibres there are more closely compacted. Likewise the Bone, being large and hallow, is not so easily broke, as if it had been solid and smaller: For of two Bones of equal Length and equal Number of Fibres, that is stronger which has the larger Diameter.

The *Blood-Vessels* usually enter the Ends of the Bones, the Arteries at one End, the Veins at the other. The *Medullary Vessels* commonly enter the Sides of the Bone, and that obliquely.

The Marrow is covered with a Membrane, wherein are inclosed little Bags. In these Bags are glandulous Bladders, serving both to secrete the Marrow from the Blood, and to receive it. Both these and the Bags have Passages into each other, whereby the Marrow has free Course. It passes first thro' the transverse Pores of the first internal Plate into the longitudinal ones. Thence it proceeds into other transverse Pores, when it alters its Course again, and exudes farther. Thus it passes alternately thro' and between the Plates, till it is diffused throughout. In this Manner it is diffused thro' Bones, whose Plates are contiguous. But where the Plates are at a Distance, the small Cells contain Glands, which directly supply the Plates with Marrow.

The Marrow not only serves to keep the Substance of the Bone moist, but to lubricate the Joints, and to hinder the Ends of the Bone, from being worn or over-heated with Motion. It also moistens the Ligaments, which tie them to each other: As do likewise the Glands found in all the Joints. The *Back-bone* hath these two Things peculiarly remarkable. 1. Its different Articulations from the other Joints of the Body. For here most of the Joints are flat, and withal guarded with Asperities and Hollows, made for catching and holding; so as firmly to lock and keep the

5. The various Parts of the Body are clothed with *Membranes*, which are whitish Tunicles, extremely thin and flexible, composed of Fibres interwoven with each other, as a Piece of Cloth is of Threads. They are fastened together by a kind of Cartilages, which are termed *Ligaments*.

6. An

Joints from Luxations, but withal to afford them such a Motion, as is necessary for the Incurvations of the Body. 2. The Difference of its own Joints in the Neck, Back and Loins. In the Neck the two upper *Vertebrae*, are curiously made, and jointed (different from the rest) for the commodious and easy bending and turning the Head every Way. In the *Thorax*, and Back, the Joints are more close and firm; and in the Loins, more lax and pliant; as also the Spines are different, and the Knobs and Sockets turned a quite contrary Way, to answer the Occasions the Body hath to bend more there, than higher in the Back. So that its Structure is the very best that can be contrived; for had it been all Bone, we could have had no Motion in our Body; had it been two or three Bones articulated for Motion, the *Medulla Spinalis* must have been necessarily bruised at every Angle or Joint; besides, the whole would not have been so pliable, for the several Postures we have Occasion to put ourselves in. If it had been made of several Bones without intervening Cartilages, we should have had no more Use of it, than if it had been but one Bone. If each *Vertebra* had had its own distinct Cartilage, it might have been easily dislocated. And lastly, the oblique Processes of each superior and inferior *Vertebra*, keep the Middle one that it can neither be thrust backwards nor forwards to compress the *Medulla Spinalis*.

The *Pelvis* made in the Belly by the *Ilium*, *Ossa Coxendicis*, and *Pubis*, is larger in a Female than in a Male Skeleton, that there may be more room for the lying of the *Viscera* and *Fetus*. So the Cartilage bracing together the two *Share-bones*, is twice thicker and laxer in Women than Men. As also is the Cartilage that ties the *Os Sacrum* to its *Vertebra*; and all to give Way to the Passage of the *Fetus*.

Another considerable Difference is in the cartilaginous Production of the seven long Ribs, whereby they are braced to the Breast-bone. These are harder and firmer in Women than in Men; the better to support the Weight of the Breasts, the sucking Infants, &c.

It is remarkable in the Joints, and a manifest Act of Caution and Design, 1. That altho' the Motion of the Limbs be circular, yet the Center of that Motion is not in a Point, but an ample superficies. In a Point, the Bones would wear and penetrate one another, and the Joints would be exceeding weak. But the Joint consisting of two large Superficies, concave and convex, some furrowed and ridged, some like a Ball and Socket, and all lubricated with an oily Sub-

6. An *Artery* is an hollow Canal, composed of Fibres closely twisted together, which conveys the Blood from the Cavity of the Heart to all the Parts of the Body. All the Arteries spring from Two, the *Aorta* or *Great Artery*, and the *Pulmonary Artery*. The latter conveys the Blood from the Right Ventricle of the Heart, thro' the Lungs, into the Left Ventricle. The former conveys it from the Left, to all other Parts of the Body. The *Pulse* which is in every Artery is only a Continuation of the Motion impressed upon it by the Motion of the Heart. ^b

7. A.

rance, they are incomparably prepared both for Motion and Strength. 2. That the Bones next the Joints are not spungy, as their Extremities commonly are, nor hard and brittle, but capped with a strong, tough, smooth, cartilaginous Substance, serving both for Strength and Motion.

For affording this oily Matter, there are *Glandules* very commodiously placed near the Joints, so as not to suffer too great Compression by the Motion of the neighbouring Bones, and yet to receive a due Pressure, to cause a sufficient Emission of the Oil into the Joints. Another Thing considerable is, that the excretory Ducts of the *Mucilaginous Glands* have some Length in their Passage from their Glands to their Mouths; which is a good Contrivance, to prevent their Mouth being oppressed by the Mucilage, and also to hinder the too plentiful Effusion thereof, but yet to afford a due Expressure of it at all Times, and on all Occasions; particularly in violent and long-continued Motions of the Joints, when there is a greater than ordinary Expence of it.

^b The Arteries ordinarily consist of Three *Coats* or *Membranes*. The Outermost has been generally thought to be composed of fine Blood-vessels. The Second is Muscular, and made of firm and strong circular, or rather spiral Fibres: Of which there are more or fewer Strata, as the Artery is larger or smaller. These Fibres are extremely elastic. The Inmost Coat is a fine, dense, transparent Membrane, containing the Blood, which otherwise would easily ooze thro' the Spiral Fibres.

On a more accurate Examination it has been found, that the Outermost Coat of all Arteries is a Cellular Substance, composed of fine, pellucid Membranes, which may be stretched even suddenly to a great Extent without breaking. And they as suddenly collapse, when that stretching Force is removed. These Cells contain an oily Liquor, which their Coats seern from the Branches of the Artery that are spread over them. This cellular Substance of the Arteries serves to connect them with the surrounding Part, without hindering their Actions or Motions. It gives a safe Passage to

7. A *Vein* is a hollow Canal, which receives the Blood from the Artery, and conveys it back to the Heart. The chief Veins are three, The *Vena Cava*, which pours the Blood thro' a wide Passage into the Right Ventricle of the Heart, the *Pulmonary Vein*, which in like Manner pours it into the Left Ventricle : And the *Vena Porta*, which does not, like the two former, end in a large Trunk, but spreads itself at each Extremity into numerous Branches.

In the Cavity of the Veins, there are certain thin Tunicles, which are termed *Valves*. These, during the regular Motion of the Blood, lie close to the Side of the inner Coat : But in case of any Obstruction, recede from it and close the Passage, to prevent the Blood's falling back.

8. The *Lymphatic Vessels* are small Canals full of Valves, consisting of a thin, transparent Tunic, which convey an extremely clear Liquid into the Mass of Blood. Probably these (as well as the Veins,) and all the other Vessels, are only Continuations of the Arteries.

9. A *Nerve* is a whitish, round, slender Body, arising from the Brain, which is supposed to convey the Animal Spirits, to all Parts of the Body. What these Spirits are none can shew : Nay we are not sure, they have any Being. For none can certainly tell, Whether the Nerves are hollow Canals, or only solid Threads, inclosed in proper Integuments.

10. The Vessels of their other Coats, and supplies Oil for lubricating them. There is also another Cellular Substance, between the Membranes and the Muscular Coat.

All the Arteries begin with a larger Trunk, and grow less and less till they are no longer seen by the naked Eye. Hence they are continued, till they anastomose with the Veins, and so form one uninterrupted Channel.

They appear white, because their Coats are of so dense a Texture, that the Blood is not visible thro' them. This proceeding from wider to narrower Canals, is continually obstructed in its Passage. But being pushed on by the Motion of the Heart, it distends the Coats, and causes that leaping Motion called the Pulse. By this, as well as by their Whiteness, Arteries are distinguished from Veins.

10. The fibrous, soft, reddish Part of the Body is termed *Flesh*. All fleshy Fibres are hollow, and divided thro' their whole Length into little Caverns, wherein the Blood is detained, as Occasion requires.

11. A *Gland* is a soft and spongy Body, which separates some particular Liquid from the Blood. The larger Glands contain Arteries, Veins and Lymphatic Vessels: But the Glands of the Intestines are only the Tops of the Arteries.

12. A *Muscle* is a bundle of Fibres joined and fastened together, with their proper Veins, Arteries and Nerves. It is divided into little Cells by transverse Fibres, parallel to each one, whereby it may be contracted and shortened, or relaxed and lengthened again. Its extreme Parts are more closely compacted, which we term *Tendons*. By these the Muscles are connected with the neighbouring Parts. A Muscle generally consists of Three Parts; The Upper, termed the *Head*, the middle, termed the *Belly*, and the lower Part, or *Tail*.

Every Muscle is divisible into smaller Muscles, and those into other still smaller: And so on, beyond all Imagination. The last and smallest Parts are Muscular

* There is a Kind of Down in the Cavity of every Gland, which probably does the Office of a Filter, and is that whereby a particular Humour is separated from the Blood.

The Structure of this Down-vessel is different according to the different Purposes of Nature. Sometimes the Liquor filtrated thro' it, falls Drop by Drop on a Membrane, to which one End of the Vessel is fastened, as where it is designed only to moisten the Part. Sometimes many of these Down-vessels spread over the inner Surface of a Membranous Cell, into which they all pour their Liquor, which is discharged at a small Orifice.

These Vessels are often of a great Length, tho' they take up little room, being wound over one another, sometimes in a single Knot, and sometimes in several, inclosed in a common Membrane. And hence is the Distinction of Glands into *Conglobate* and *Conglomerate*.

A *conglobate* Gland is a little, smooth Body, wrapt up in a fine, double Skin, with only an Artery and Nerve passing in, and a Vein and *Excretory Duct* going out.

A *conglomerate* Gland is an irregular Assemblage of several simple Glands, which are tied together and wrapt up under one common Membrane.

cular Fibres. But there is no assignable Point in any Muscle, wherein there is not some Nerve. And here all the Nerves disappear; (In other Parts their Extremities expand into Membranes.) It is therefore probable, that the Muscular Fibres, are only the Nervous continued.

13. The *Cuticle* or *Scarf-Skin* is an extremely thin and transparent Membrane, void of Sense, and covering the *Skin* all over. ^d The *Skin* covers almost the whole Body, and is formed of whitish Fibres, intermixt with numberless Branches of Nerves, Veins and Arteries. On its Surface are many Furrows or indented Lines, having generally Hairs on each Side, and *Pores*, or little Holes of various Sizes, serving for the Transpiration of superfluous Particles. Under the Skin lie the *Subcutaneous Glands*, which are supposed to transmit thro' the Pores an insensible Steam, commonly believed to be of the same Kind with what, when sensibly thrown out, is called *Sweat*. ^e

14. *Fat*,

^d The *Cuticle* sticks fast to the Surface of the *Skin*, to which it is also tied by the Vessels that feed it. It consists of several Layers of exceeding small Scales, which cover one another where it is thick. But in the Lips, where it is extremely thin, they little more than touch one another.

In some Creatures, (as Fishes) these Scales are only the excretory Ducts of the Glands of the Skin. In others those Glands have their proper Ducts, opening between the Scales.

It is supposed, there are in one Scale 300 Excretory Ducts, and that a grain of Sand will cover 250 Scales. If so, a Grain of Sand will cover 125000 of our Pores.

The *Cuticle* serves to defend the Nerves of the Skin, both from the Air, which would dry and make them less sensible, and from rough and hard Bodies, which would make a painful Impression on the naked Nerves.

Negroes have a Skin between the *Cuticle* and the true Skin. They are born white; but the middle Skin, in a little Time turns black and gives that Colour to the whole Body.

^e Thro' the Pores there continually transudes a subtle Vapour from every Point of the Body, being what redounds of the Aliment, comminuted to the highest Degree, and sent to repair every Particle of it. And the Matter thus evacuated is more than is thrown out, by all the other Passages together.

A Person of middle Age found what he perspired was five Eighths of the Food taken in: So that there remained only three Eighths for

14. *Fat*, a whitish, oily Substance, void of Sense, is secreted from the Blood, and lodged in small, oval, membranous

Nourishment and all other Evacuations. He observ'd also, that as much is perspired in one Day, as passes by Stool in fourteen : And more particularly, that in a Night's Time about Sixteen Ounces are usually thrown out by Urine, four by Stool, and about forty by insensible Perspiration.

If a Man eats and drinks Eight Pounds in a Day, five Pounds of it pass by Perspiration : Namely, about One Pound within five Hours after Eating ; (Perspiration being least of all soon after Eating) from the fifth to the twelfth Hour, about three Pounds, and from the 12th. to the 16th. scarce half a Pound. Exercise increases Perspiration much. But it is naturally less in Women than Men.

While this Steam flows from our Body, it constantly imbibes a Supply of Moisture from the Air, which serves to keep all its Parts soft, pliant and fit for Motion. Hence, from the greater Moisture of the Air, we perspire less in Winter than in Summer, and in rainy Weather than in fair. Live therefore if possible, in a clean House, and in a pure, dry Air.

This Inhalation is very considerable. Dr. Keil found his Body to have imbibed in one Night Eighteen Ounces of Moisture. And on a sudden Change of Weather from dry to wet, the Inspiration sometimes exceeds the Expiration : There being *Absorbent-Veins*, which accompany the numberless Arteries from which the Perspiration is discharged. To the Matter thus imbibed (not the Obstruction of the Pores) he ascribes what we term a *Cold*. Sweating cures this, by throwing out the noxious Matter which was imbibed before.

The Benefits of insensible Perspiration are so great, that Life cannot be preserved without it. And the Subtility, Equability and Plenty of what we perspire, are the grand Symptoms of Health.

But how little do we know even of our own Frame ! It has hitherto passed as an unquestionable Truth, that the same Matter which passes by insensible Perspiration, passing in greater Quantities, is Sweat. Whereas an ingenious Physician, Dr. Rogers, has found by numerous Experiments, That a person perspires abundantly less, when he Sweats than when he does not : That one who perspires 24 Ounces in seven Hours Sleep, if he sweat, does not perspire above Six. This he has tried many Times, and never found it to fail. Whence he infers, 1. That it is not the same Matter which is evacuated by insensible Perspiration and by Sweat : 2. That it is not evacuated thro' the same Pores : 3. That the Sweat-Pores are abundantly larger and fewer, than those which serve insensible Perspiration : 4. That Sweat greatly hinders that Perspiration, both by covering those Pores with a clammy Liquor, and by constricting them so that they cannot open ; which must be the Case, when the Sweat-Pores are dilated. What a Field does this open !

membranous Bags, which shoot out of the Arteries. It is found in various Parts, but chiefly under the Skin, where (unless a Man be emaciated) it runs co-extended with the Skin over most Parts of the Body.

15. The Fourth General Integument is the *Panniculus carnosus*, which in some Parts is of a fleshy Substance, in others a mere Membrane, lying just under the Fat.

16. The Dissimilar Parts are composed of the Similar. The chief of these is the *Head*. The Cavity of the *Skull* is nearly filled with a soft Substance, termed in general The *Brain*. But this is properly that Part of it which lies forward. The Hinder Part (considerably smaller) is called the *Cerebellum*. Under both, but chiefly the latter, and springing from the internal Substance of both, is the *Medulla Oblongata*.

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17. All

^f Fat is secreted from the Arterial Blood by the *adipose Glands*, and transmitted again from the membranous Cells to the Blood thro' the Veins. It seems to be a Portion of the Blood coagulated by the nitrous Air mixt with it in the Lungs. Artificial Fat is made, by mixing for some Days Oil of Olives with Spirit of Nitre. Hence divers Animals grow fat in frosty Weather, the Air then abounding with Nitre.

It is a natural Balm that, by enveloping the Salts of the Blood, keeps them from corroding the Parts thro' which they pass. It likewise nourishes the Body. And hence fat Persons are able to bear much Abstinence.

Yet too much Fat is a real Disease, which hinders the Motion of the Lungs, intangles the most active Particles of the Blood, and naturally creates Dulness and Heaviness.

You may cure this, by following Three plain Rules: Eat and Drink little; Sleep little; Work much.

^s The *Skull* is divided into two Plates, one laid over the other. Between these is a spongy Substance, made of bony Fibres detached from each Plate. Hereby the Skull is made not only lighter, but far less liable to Fractures.

The Skull is covered with a Membrane called the *Pericranium*. This has several Holes, which give Passage to the Spinal Marrow, the Nerves, Arteries and Veins. But these fill them so nicely, that nothing can pass into, or out of the Head but thro' these Vessels.

It is round, that it may contain the more; but a little depressed and longish, advancing out behind, and flatted on the Sides, which contributes to the Enlargement of the Sight and Hearing.

17. All these are involved in two Membranes, the Inner (called *Pia Mater*) extremely thin; the Outer, (called *Dura Mater*) considerably harder and thicker. Where they involve the Cerebellum, there is interposed between them the *Arachnoidea*, a very subtle and transparent Membrane, which descending thro' the hinder Part of the Skull, together with them involves the whole *Spinal Marrow*.

18. The Outer Part of the Brain (called the *Cortex* or *Bark*) is of an ashy or greyish Colour. It is formed from the minute Branches of the neighbouring Arteries, which being wove together in the *Pia Mater*, inclose the Inner Part, ordinarily to the Thickness of about half an Inch.

It consists therefore of innumerable little Glands, contiguous to each other, (supposed to secrete the Animal Spirits) which are of themselves oval, but by their mutual Pressure become angular, and run waving with each other.

The Inner Part (called the *Medulla*) is white, and terminates in another medullary Substance, very white and hard, called the *Corpus callosum*. The Medulla is thought to consist of fine Tubes, which when collected into little Bundles, and covered with Membranes, are termed Nerves.

19. To trace this a little farther. From every Point of the Outer Brain arise minute Fibres, which in their Progress uniting together, are easily perceptible. These constitute the Substance of the Inner Brain, and of the *Spinal Marrow*. In their farther Progress they are distinguished by Coats detached from the two Membranes of the Brain, into several Bundles called *Nerves*, resembling so many Horse-tails, each wrapt up in a double Tunic.

Several of these part from the rest, in the Brain itself, of which there are Ten Pair; One on each Side. From the *Spinal Marrow* there arise Thirty Pair more.

All

It is divided into Pieces by four Sutures. This makes it less liable to break, gives Passage to the Membranes of the *Pericranium*, and Vent to the Matter of insensible Perspiration.

All the^{se}, while within the Skull or the Spine, are pulposus; but afterwards harden, acquire a Coat, and spread thro' the smallest Points of the solid Parts of the Body. Their Coats are every where furnished with Blood-Vessels, Lymphatics, and Vesicles of a very tight Texture, which serve to collect, strengthen and contract their Fibres.

And if we consider

1. The great Bulk of the Brain, Cerebellum and Spinal Marrow (whereof the whole Substance goes to constitute Nerves, being continued into, and ending in them :) 2. The great Number of Nerves distributed hence, throughout the whole Body: 3. That the Brain and Spinal Marrow are the Basis of an Embryo, whence the other Parts are afterwards formed: And lastly, That there is scarce any Part of the Body, which does not feel or move: It may seem not altogether improbable, that all the solid Parts of the Body, are woven out of nervous Fibres, and wholly consist of them.

20. The Brain is divided ^h into four *Ventricles*.
Near the Rise of the Fourth, there is a round Hole,
C 1 over

^h The Brain is abundantly bigger in Proportion in Man than in other Animals. In other Animals, it is biggest, *ceteris paribus*, in those that have most Sagacity.

There are in the Brain Multitudes of Vessels so extremely small, that if a Globule of Blood (a Million of which exceed not a Grain of Sand in Bigness) were divided into 500 Parts, those Parts would be too large to pass thro' them. And these Vessels are as large in the Brain of a Sparrow, as in that of an Ox. Nor is there any Difference between the Brain of a large Animal and a small, but that one contains far more of these Vessels than the other. But the Globules of the Fluid passing thro' them are in all Animals of the same Size.

The outer Part of a Turkey's Brain is a very clear and transparent oily Matter. Innumerable fine Blood-Vessels are spread thro' every Part of this. And if a small Part is cut, there flows out a small Globule of pellucid Fluid.

The Brain is not absolutely necessary to Animal Life. Infants have been born, and lived some Time without any. We have an authentic Account from *Paris*, of a Child that survived the Birth four Days, not only without a Brain, but even an Head: Instead of which it had a Mass of Flesh, somewhat like Liver. In 1673, a Child was born alive without any Brain, Cerebellum or Medulla oblongata; The Skull being solid: Nor had it any Communication

over which is suspended the *Pineal Gland*, so called from its resembling the Shape of a Pine-Apple. It is furnished with Veins and Arteries, and inclosed in a thin Membrane, derived from the *Pia Mater*. *Des Cartes* imagined this to be the Seat of the Soul; but without any solid Reason. Nor has any one yet been able to discover, what is the Use of it. Is it such a Reservoir of Blood for extraordinary Occasions, as some imagine the Spleen to be?

21. The *Eyes* next offer themselves to our Observation, guarded by the *Eye-lids*, *Eye-lashes* and *Eye-brows*. The *Eye-lids* consist of the *Cuticle*, the *Skin*, a thin Expansion of the *Panniculus carnosus*, and an Inward Coat. A Palisade of short, but stiff Hairs grows out of their cartilaginous Edge, both to break the too fierce Impression of the Rays of Light, and to prevent any Thing from getting into the Eye, when open. These Hairs only grow to a convenient Length, and their Points stand out of the Way, those of the Upper *Eye-lids* being bent upward, and those of the Lower, downward. Meantime the *Eye-brows* hinder Sweat, or any Thing else which might be hurtful, from falling down from the Forehead.

Both the *Eye-lids* are moveable, but chiefly the Upper. Animals which have hard Eyes, as Lobsters, need none, and therefore have no *Eye-lids*. But most Brutes have an additional *Eye-lid* (called the *Nictitating Membrane*) which draws like a Curtain, to wipe off what might incommode the Eye. The Monkey indeed has it not, as being furnished with Hands like a Man.

22. The Eye can move upward, downward, to either Side, and round, either toward the Right or Left.

with the Spinal Marrow. Mr. *du Verney* took out the Brain and Cerebellum of a Pigeon: Yet it lived and walked about. *Mons. Ghisac* took out the Brain of a Dog; yet he lived. On taking out the Cerebellum, he seemed dead; but revived, when he blew into the Lungs and continued alive an Hour. Nay, there are many Instances of Insects living a long Time, after their Head is cut off. Hence it appears, that the Spinal Marrow alone may, for a Season, suffice both for Life, Sensation and Motion.

Left. For these six Motions six Muscles are allotted, which spread their Tendons far into the Eye. At each inner Corner of the Eye, there is a Gland with two or three Ducts, which opening on the inner Surface of the Eye-lid, keep the Eye-ball moist, to facilitate its Motion. By these Glands Tears also are secreted. The Eye is connected with the surrounding Bones by the *Tunica adnata*, commonly called, *The White of the Eye*; In the midst of which is a large Hole for the *Tunica Cornea*, thro' which the *Iris* and *Pupil* appear. The whole Ball of the Eye rises from the *Optic Nerve*, and is formed of three Coats propagated from it, and as many Humours; Two of which have each a Coat of its own also. The Eye therefore has five Coats in all: Three common, and Two to contain their several Humours.

23. The Outermost Coat, proceeding from the *Dura Mater*, and surrounding the whole Eye, is termed the *Sclerotica*: The Forepart of it being transparent like Horn, is thence stiled the *Cornea*. This is more convex than the rest of the Eye. It is composed of several parallel Plates, which are nourished by many Blood-vessels, but so fine, as not to hinder the smallest Rays of Light. It has an exquisite Sense, that on the least Touch of any Thing, the Tears may be expressed, to wash off any Filth, which by adhering to it might render it dim or cloudy. The rest of the *Sclerotica* is opaque, and of the same Colour with the *Dura Mater*.

The Second Coat is called the *Uvea*. It is much thinner than the former, tho' thicker than the *Pia Mater*, from which it proceeds. In the Forepart of it is a round Hole, which with the Chrystalline Humour interposed, constitutes the *Pupil*, surrounded by the *Iris*, so named, from its supposed Resemblance to the Colours of the Rainbow. The Third and inmost Coat is termed the *Retina*. It is extremely thin and soft, and darker-coloured than the lower Part of the *Optic Nerve*, of which it is a Continuation.

A late Writer asserts, "The *Retina* is not, as is supposed, the great Organ of Vision. By late Experiments it appears, that it is as transparent as the Humours, and consequently not a proper Instrument,

to stop and terminate the Rays of Light, or to receive the Images of Objects. The Light passes thro' this, and can only be stoppt by the *Choroides*, which is opaque, and consequently bids much fairer, for being the principal Organ of Vision: As, being black, it absorbs all the Rays and reflects none. Likewise the Action of Light is stronger on black than on any other Colour. The Situation of the *Choroides* behind the Retina, is another Circumstance in its Favour. So the Skin, the principal Organ of Feeling, is placed beneath the Cuticle. The Retina seems to be a Kind of Secondary Organ, serving to preserve the *Choroides*, (as the Cuticle the Skin) and to break the too strong Impression of the Rays upon it. Add to this, that the Retina is insensible, as proceeding from the Medulla of the Brain: But the *Choroides*, arising from the *Pia Mater*, is acutely sensible. The Optic Nerve is not composed of Fibres, like the other Nerves; but is only Part of the Medulla, inclosed in a Canal. This shews that the Retina is not a Membrane (as has been hitherto supposed) but only a Dilatation of the Medulla, inclosed under two Membranes. Perhaps it may serve to filterate the Spirits necessary for the Action of Vision. But the Vibration whereon the Sensation follows, must be made on a more firm and solid Part."

24. The *Aqueous Humour*, resembling the Colour and Consistence of Water, lies in the forepart of the Eye, just behind the Cornea: Its interior Surface is convex, the other a little concave. Whence this Humour is derived we cannot tell: but its Source must be plentiful: For if the Coat containing it be so wounded, that all the Humour runs out, it needs only to keep the Eye close for a Season, and the Wound will heal, and the Humour recruit.

Indeed an eminent *Italian* affirms, That he has slit the Pupil of divers Animals, and squeezed out all the Humours, and has afterwards restored them perfectly to Sight: Nay, that the Eyes of many, instead of being damaged thereby, seemed more lively and vigorous than before.

The Second Humour, termed (improperly enough) the *ChrySTALLINE*, consists of many thousand Filaments, tending

tending from the Circumference to the Center, and closely woven together into thin Scales. It is a little convex before, and more behind. It serves to refract the Rays of Light, so that they may meet and form an Image, on the Bottom of the Eye. It is set in the Forepart of the Vitreous Humour, like a Diamond in its Collet, and is retained there by a Membrane that surrounds it, thence called its *Capsula*. It is toward the Outside like a Jelly, but toward the Center as hard as Salt. The Figure of the Outer Part is varied by a Ligament annex, which can either make it more or less convex, or move it to or from the Retina. And this is absolutely necessary, in order to distinct Vision: For as the Rays of distant Objects diverge less than those of near Objects, the Chryselline must either be made less convex, or be set farther from the Retina.

When dried, it appears to consist of a vast Number of thin, round Scales one upon another, 2000 of which have been counted in one Chryselline. Each of these consists of a single Fibre, wound this Way and that, in a stupendous Manner, so as to run several Courses, and meet in as many Centers, and yet not interfere or cross in any Place.

The Third, which is termed the *Vitreous Humour*, is not unlike melted Glass. It is covered with an exceeding thin Coat. The Forepart is concave, as receiving the Chryselline; the other Side is convex.

25. We

The whole Apparatus of the Eye tends to this, that there be produced in the Bottom of it, a distinct Collection of all the Rays, which preceeding from any Point of an Object, penetrate the Chryselline Humour, that so an Image of that Object may be painted there. In order to this, the Rays striking on the Cornea, are reflected toward the perpendicular, and thus directed thro' the Pupil to the Chryselline. Meantime the Iris, contracting or dilating the Pupil, admits fewer or more Rays, as the Object is more or less vivid.

Now the flatter the Cornea is, the fewer Rays does it collect and transmit to the Chryselline, and those more diverging. The rounder it is, the more Rays does it collect and transmit, and those more converging. It is too flat in Old Men; it is too round in them that are Short-sighted. The Rays transmitted thro' the Pupil to the Chryselline Humour, are there refracted anew, collected and rendered converging, and those that come from the same Point, are

25. We proceed to the *Ear*, formed with exquisite Wisdom, for the Reception of Sounds. The *Outward Ear* consisting of an Oval Cartilage, externally convex, concave within, leads by various Windings to

thrown in one Point on the Bottom of the Eye. But if the Chrystalline be too dense, the *Focus* (or Point wherein they unite) will be too near: If that be not dense enough, it will be too remote. And this is another Cause of Short-sightedness, or the contrary Defect.

In all Vision both the Eyes are used at once. And both together (as any one will find upon Trial) behold an Object in another Situation than either of them apart would do. Hence a Gentleman who had one of his Eyes struck out, for some Months after was apt to mistake the Situation of Things: And when he attempted to pour Liquors into Phials, often poured them quite beside the Neck of the Phials.

The *Form* of the Eye is the most commodious which can be imagined. It is fittest both to contain the Humours within, and to receive the Images of Objects from without. Was it square, or of any multangular Form, some of its Parts would lie too far off, and some too high those lenticular Humours, which by their Refraction cause Vision. But by Means of this Form, the Humours are fitly placed to perform their Office of Refraction, and the little darkened Cell neatly adapted to receive the Image of the Object.

Again. As it is necessary for the Eye to move various Ways in Order to adjust itself to various Objects, so by this Figure it is well prepared for such Motions, and can with Ease direct itself as Occasion requires.

No less commodious is the *Situation* of the Eye: In the most eminent Part of the Body, and near the most sensible Part, the Brain. By its Eminence in the Body, it can take in the more Objects: And by its Situation in the Head, beside its Nearness to the Brain, it is most conveniently placed for Defence and Security. In the Hand it might have been more ready for Service: But to how many Dangers would it have been exposed? The same may be said, as to its Site in any other Part but where it is. But the Head is a Part that seems contrived and made, chiefly for the Use of the principal Senses.

In some Men the Iris has a Faculty of darting out Light. Dr. *Willis* mentions one, who after drinking Wine plentifully, could see to read in the darkest Night. And *Pliny* records of *Tiberius Cesar*, that if he awaked in the Night, he could see every Thing for a while, as in the broad Day-light. Dr. *Briggs* gives a parallel Instance of a Gentleman in *Bedfordshire*.

We find various Substitutes for the Use of the Eyes, in many blind Persons. In some the Defect has been supplied, by an excellent Gift of remembering what they had seen: In some by a delicate Sense of Smelling: In others, by a fine Sense of Hearing. So *Richard Clutterbuck* of *Redborough* in *Gloucestershire*, who was Stone-blind, had so curious an Ear, that he could hear the fine Sand of as

to the *Meatus Auditorius*, which is first cartilaginous, and then bony. It is filled with a viscid Matter, called the *Ear-wax*, which is supplied from the Vessels placed in the Skin, surrounding the *Meatus*, to hinder any hurtful Animal from creeping into the Ear. The *Meatus* is closed within by a thin, dry, transparent Membrane, affixt to a bony Circle, which is called the *Membrana Tympani*. Behind it is that Cavity of the *Os Petrosum*, which is termed the *Drum*.^k

26. In

Hour-Glass fall. In some it has been supplied by an exquisite Sense of Feeling: So the same *Richard Clutterback* was able to perform all Sorts of curious Works. He could not only take a Watch in Pieces, and set it together again, but could also make all Sorts of String-musical Instruments. He likewise played on them by Notes cut in their usual Form, and set upon protuberant Lines on the Wood. Yet even this hardly came up to the Skill of *Van-Eyck*, the Organist of *Utrecht*, who, tho' he had been blind from two Years old, played on all Sorts of Instruments.

Others have been able to take a Face by the Touch, and mould it in Wax with the utmost Exactness: As was the blind Sculptor, who thus took the Likeness of the *Duke de Bracciano*, and made a marble Statue of King *Charles* the First extremely well.

But more than all this, some Persons have been able even to distinguish Colours by the Touch. *Peter of Maesricht*, tho' perfectly blind, distinguished by his Touch the different Colours of Cloth. *John Vermaesen* of *Utrecht* did the same, judging by the different Degrees of Roughness which he felt.

Yet blind Persons, even tho' they distinguish them by the Touch, have no Idea of visible Objects. Thus the Gentleman couched by Dr. *Cbeselden*, tho' he knew the Colours in a good Light during his former State, yet when he saw them after couching, could not distinguish them, by the faint Ideas he had of them before. It was even a considerable Time before he could remember, which was the Cat, and which the Dog without feeling them. Add to this, that he had no Idea of Distance, but imagined all the Objects he saw, touched his Eyes, in the same Manner as those he felt did his Skin.

^k The outward Ear has two Parts, That which stands out from the Head, called the *Auricle*, and the narrow Passage which enters the Skull, called *Meatus Auditorius*.

The *Auricle* is furrowed with divers winding Canals, which receive and collect the various Undulations of the Air. They who have lost this, hear very confusedly, unless they use a Trumpet, or form a Cavity round the Ear, with their Hands.

26. In this, besides a little Branch of Nerves, there are four little *Bones*, two *Passages*, and two *Windows*. Three of those *Bones*, from some imagined Resemblance, are stiled the *Hammer*, the *Anvil* and the *Stapel*: The Fourth is termed, *The orbicular Bone*. These are fastened by strong Ligaments to each other, and to the neighbouring Parts. The *Passages* go from the Side of the *Drum*: One of which, termed the *Labyrinth*, by a very winding Way, carries a Part of the Auditory Nerve to the external Muscles of the Head. The other passes from the Bottom of the *Drum* to the *Palate*; whereby not only Air, if needful, may be received, but the Defect of Hearing, in some Measure supplied by speaking to the Mouth.

The *Labyrinth* contains, besides the Entrance, three bony, semicircular Cavities, and a bony Canal, in the Form of a *Screw*, divided into two Parts, from the Top to the Bottom. The *Labyrinth* is lined throughout with a thin Membrane, furnished with Veins, Arteries and Nerves. And this Membrane may not improbably be the Organ of Hearing.

The curious Structure of the *Labyrinth* and *Screw* tend to make the weakest Sounds audible. Those Canals, by their Winding, contain large Portions of the

It is a wise Provision, that the Substance of the Auricle is cartilaginous. Had it been Bone, it would have been troublesome, and might by many Accidents have been broken off. If Flesh, it would neither have remained expanded, nor so well have received or conveyed the Sounds. Rather it would have blunted them, and retarded their Progress into the Organ. But being hard, and curiously smooth and winding, Sounds find an easy Passage, with a regular Refraction, as in a well-built Arch.

It is observable, that in Infants in the Womb and newly born, the *Meatus Auditorius* is close shut up, partly by the Constriction of the Passage, and partly by a glutinous Substance, whereby the *Drum* is guarded against the Water in the *Secundine*, and against the Injuries of the Air, as soon as the Infant is born.

It is remarkable, that in the Ears of most if not all Animals, where the *Meatus Auditorius* is long enough to afford Harbour to *Ear-wigs*, or other Insects; *Ear-wax* is constantly to be found. But in Birds, whose Ears are covered with Feathers, and where the *Drum* lies but a little within the Skull, no *Ear-wax* is found, because none is necessary to the Ears so well guarded, and so little tunnelled.

the *Auditory Nerve*, upon every Point of which at once the Sound being impress'd becomes audible ; and by their Narrowness, the Sounds are hindered from dilating, which must have weakened them proportionably.

The Strength of the Impression is likewise encreased by the Elasticity of the Sides of the bony Canal, which receiving the first Impulses of the Air, reverberate them on the *Auditory Nerve*.

The *Auditory Nerves* are distributed, One to the Ear, the other to the Eye, Tongue and Parts adjoining. By the Distribution thereof to different Parts, an admirable Consent is established between them. Hence it is, that most Animals, hearing a strange Sound, erect their Ears to catch it, open their Eyes, and are ready with their Mouth, to shriek or call for Help. A farther Use of this nervous Communication between the Ear and the Mouth is, that the Voice may correspond with the Hearing, and be a Kind of Echo thereof : and that what is heard with one of these Nerves, may readily be expressed by the Help of the other.

And now what less than an infinitely wise God, could contrive so fine an Organ, and such a Medium, so susceptible of every Impression, that the Sense of Hearing hath Occasion for, To empower all Animals to express their Meaning to each other, with endless Variety ? Yea, what less could form such an Economy as that of Music is ? So that the Medium conveys the melodious Vibration of every Animal Voice or well-tuned Instrument, and the Ear receives them, to allay the Perturbations, and calm and cheer the Heart of Man ?

27. The

I Tho' the Ear be the ordinary Organ of Hearing, yet it is not the only one. We may hear by the Teeth. For if one End of a Knife be applied to a Spinnet, and the other held between the Teeth, the Music will be distinctly heard, tho' the Ears be ever so closely stopp'd. Yet this is not properly, by the Teeth, but by the *Auditory Nerve* which passes from the Drum to the Palate.

In those who are born Deaf, the Eyes may in some Measure serve in the Place of Ears. Some can understand what is said, by nicely observing the Lips and Tongue of the Speaker : And may even

27. The *Nostrils* are made not of Flesh or Bone, but of Cartilage, the better to be kept open, and as occasion requires, to be dilated or contracted: For which purpose they are furnished with proper and curious Muscles. The Tubes therein growing narrower and narrower, lead into several little Cells and winding Cavities, covered with a soft Coat, and provided with Arteries, Veins, Glands, and Filaments of the *Olfactory Nerves*. This therefore is without all Doubt the proper Organ of Smelling.

And forasmuch as it is by Breathing, that the odorant Particles are drawn in, the *Laminae* with which the upper Part of the Nose is barricaded, serve two excellent Purposes, partly to prevent any Thing hurtful from entering the breathing Passages in our Sleep (for which End likewise the Hairs placed at the Entrance of the *Nostrils* serve) and partly to receive the Divarications of the *Olfactory Nerves*, which are here thick spread, and by this Means meet the Smells entering with the Breath.

28. The *Tongue* has for its Basis that forked Bone, called the *Os Gutturis*. It consists of various Muscles interwoven together, that it may be fit for various Kinds of Motion. To these are added very many small Branches of Nerves, which pass thro' the Middle of it to the Outside, and being gathered into little Bundles,

accustom themselves to use their own; till they learn a Kind of Speech. Thus a Physician at *Amsterdam* taught several Children born deaf, to understand what was said, and to give pertinent Answers.

Mr. *Gaddy's* Daughter of *Geneva* lost her Hearing at two Years old. Yet by observing the Lips of others, she had acquired many Words, whereby she would talk whole Days with those that could understand her. But she knew Nothing of what was said, unless she saw the Mouth of the Speaker: So that if they wanted to speak to her in the Night, they were obliged to light a Candle. Only she knew what her Sister said even in the Dark, by laying her Hand on her Mouth.

But many deaf Persons can hear, if a loud Noise be made while you speak. Dr. *Willis* mentions one, who, if a Drum was beat in the Room, could hear very clearly. So that her Husband hired a Drummer for his Servant, and by that Means conversed with her daily.

Bundles, constitute those *Papillæ*, which make its Surface rough and uneven. Beside these there appear also on the Surface of the Tongue, certain pointed Fibres, not unlike the Ends of Birds Claws, inclining toward the Basis of it, with which are interspersed innumerable *Salival Glands*. And all these are in their several Ways subservient to the Sense of *Tasting*.

The Time of cutting the *Teeth* is usually from the Seventh to the Seventeenth Month. It is commonly preceded by an itching of the Gums, and by Convulsions, Fevers and Looseness: most of which Symptoms happen to Birds also, upon moulting or casting their Feathers. The Seed of the Teeth is a mucous Matter, like the white of an Egg, contained in the Cells of the Jaw-bone, which grows harder and bigger till it breaks thro' the Gum.

That Part of the Tooth which stands out of the Gum, is covered with a peculiar Substance called *Enamel*. It is composed of an infinity of little Tubes, which grow on the Bone by their Roots. If any Part of this be broken off, so that the Bone is left bare, it grows carious; there being no Bone which will bear the Air.

We may farther observe, 1. That the Teeth only of all the Bones, grow in Length during a Man's whole Life: which is providently designed, to repair the Waste that is continually made by Attrition; 2. That the Teeth are the only Bones which are not covered with that exquisitely sensible Membrane, the *Periosteum*; 3. That they are harder and firmer than any other Bone, that they may be more durable and fit to chew the most solid Aliments; 4. That for their Nourishment, there is a Cavity contrived in each Side of the Jaw-bone, in which are lodged an Artery, a Vein and a Nerve, which thro' smaller Cavities send their Twigs to every Tooth; 5. That as Infants are designed to live on Milk for some Months, they are so long without any Teeth: Whereas Animals that need them, have them sooner, and some are even born with them. 6. The different Shape of the Teeth is remarkable. The Fore-teeth

are formed broad, and with a thin and sharp Edge, like Chissels, to cut off a Morfel from any solid Food. The next, One on each Side, are stronger, deeper-rooted, and more pointed, to tear tougher Aliments: The rest are made flat and broad at Top, and withal somewhat uneven, that thereby they may the better retain, grind and mix the Aliment. 7. Because Biting and Chewing require much Strength, partly in the Teeth themselves, partly in the Instruments that move the lower Jaw, which alone is moveable; Nature has given it strong Muscles, which make it bear forcibly against the Upper Jaw: And has not only fixt each Tooth in a distinct Cavity, as in a close, strong and deep Socket, but has given Holdfast to the several Sorts of Teeth, suitable to the Stress that is to be laid upon them. So whereas the *Cutters* and *Eye-teeth* have only one Root, the *Grinders*, designed for harder Work, have Three: In the Upper Jaw, often Four, because they are pendulous, and the Substance of the Jaw somewhat softer. 8. The Situation of the Teeth is most convenient. The *Grinders*, are behind, near the Center of Motion, because chewing requires a considerable Force: The *Cutters* before, ready for their easier Work.

29. The *Palate* is of a bony Substance, a little concave, and cloathed with a thick Membrane, which Has the same Kind of nervous *Papillæ* and small Glands, that are seen in the Surface of the Tongue. And hence it is qualified to assist the Taste as well as the Speech.

It would be endless to specify the curious Mechanism of all the Parts that concur to form the Voice. However let us note two Things. 1. There are Thirteen Muscles provided for moving the five Cartilages of the *Windpipe*. 2. It is amazing that the *Glottis* (the upper Part of the Wind-pipe) can so exquisitely contract or dilate itself, to form all Notes. "Suppose (says Dr. Keil) the greatest Distance of the two Sides of the Glottis to be one Tenth of an Inch, in sounding Twelve Notes, (to which the Voice easily reaches) this Line must be divided into 12 Parts, each of which gives the

the Aperture requisite for such a Note. But if we consider the subdivision of Notes into which the Voice can run, the Motion of the Sides of the Glottis is still vastly nicer: For if of two Chords, sounding exactly Unisons, one be shortened but the two thousandth Part of its Length, a just Ear will perceive the Disagreement and a good Voice will sound the Difference: And yet this is only the one hundred and ninety sixth Part of a Note. But suppose the Voice can divide only into an hundred Parts, it follows, that the different Apertures of the Glottis, actually divide the tenth Part of an Inch, into twelve hundred Parts, the Effect of each of which produces a sensible Alteration upon a good Ear.

30. The *Uvula* is a round, oblong, fleshy Substance, suspended near the Passage from the Mouth into the Nostrils, and probably designed to hinder the cold Air, from rushing too fast into the Lungs. The *Tonsils*, or Almonds of the Ear, are two small Glands, placed at the Root of the Tongue, which supply an Humour, to keep the Mouth and the Tongue continually moist.

The *Wind-pipe* is wonderful in its Conformation: Because continual Respiration is necessary, it is made with *Annular Cartilages*, to keep it constantly open, that its Sides may not fall together: And lest, when we swallow, any Particle of Food should fall in, which might cause Convulsions, or even Death, it has a strong Shutter, or Lid, called the *Epiglottis*, which, whenever we eat or drink, falls down of itself, and covers it close, so that no Crum or Drop can enter. It is for the more convenient bending of our Necks, that the Wind-Pipe is not made of one entire continued Cartilage, but of many circular ones.

What is farther remarkable in these Cartilages is, that all the Way where they are contiguous to the Gullet, they are membranous, to give an easy Passage to the Food: But after that, they are, some completely round, some triangular. Another observable is, in the Wind-Pipe, the Cartilages run parallel to each other: But, in the Lungs, the lower Parts of the Superior Cartilages,

tilages, receive the upper Parts of the Inferior: Hereby enabling them to contract themselves in Expiration, and to dilate in Inspiration.

31. The *Hairs* are all hollow. The Root of each Hair is fixt in a mucous Globule, of an oval Figure, which often adheres to it, when it is pulled up by the Root. They are jointed like a Reed or Cane, and shoot out into small Branches. They serve not only for a covering, but also for the Excretion and Expiration of an oily Matter.

Every Hair does properly live, and receive Nourishment like the other Parts. The Roots do not turn White or Grey in Age, any-sooner than the Extremes. But the whole of each Hair changes Colour at once. Or (to speak more properly) the Hairs of another Colour fall off, and white ones grow in their Place.

Yet, its Life is of a peculiar Kind, and approaches to the Nature of Vegetation. Hairs grow much as Plants grow out of the Earth, or as some Plants grow upon others: From which they draw their Nourishment, and yet each has its Life distinct from the other. So Hair derives its Food from some Juices in the Body, but not from the nutritious Juices. Accordingly the Hair may live and grow, while the Body is starved to Death. ^m

All

^m That Hair may grow, merely as an Excrecence of the vegetable Kind, appears from that memorable Case recited by Mr. Hook, of a Body which, having been buried forty-three Years, was found in a Manner wholly converted into Hair. The Woman was buried in a Coffin of Wood, and lay the lowest of three in the same Grave. The others being removed and this Coffin appearing, it was observed, that much Hair came thro' the Clefts of it: On removing the Lid, the whole appeared a very surprizing Sight. There was the whole Figure of the Corpse, exhibiting the Eyes, Mouth, Ears and every Part. But from the very Crown of the Head, even to the Sole of the Foot, it was covered over with a very thick set Hair, long and much curled. The People, amazed at this Appearance, went, to touch the Corpse. But the Shape fell away, as it was handled, leaving only a Quantity of shapeless Hair, but neither Flesh nor Bones, only a small Part of the great Toe of the right Foot.

Each Hair consists of several smaller ones, wrapt up in one common Covering. They send out Branches at the Joints. The Root

All Hairs appear round. But the Microscope discovers some of them to be square, others triangular; which Diversity of Figures arises merely from the Diversity of the Pores. Their Length depends on the Quantity of Humours proper to feed them, and their Colour on the Quality. And hence the Colour usually differs in the different Stages of Life.

The Hair of a Mouse is a transparent Tube, with a Pith of small Fibres convolved, running in some Hairs spirally, in some transversely, in others from Top to Bottom.

32. We proceed to the middle Cavity of the Body. Herein the principal Part is the *Heart*, consisting of a strong Tendon, extended obliquely from the *Basis* or broader Part, to the *Conc*, into which the fleshy Fibres are inserted, in an elegant Series, with a spiral Bending, one half opposite to, and crossing the other: By which Means the grand Muscle is admirably fitted, both to receive and to propell the Blood. It has two great Cavities, usually termed the *Ventricles of the Heart*. They are divided from each other by an intermediate Part, called the *Septum*, constituted by the same Fibres, which is convex on the Side next the Right Ventricle, and concave on the other. The *Vena Cava* is inserted in the right Ventricle, and two Inches from its Insertion, divides into the *upper* and *lower*. The former brings the Blood into it from the upper, the latter, from the lower Parts of the Body. The *Pulmonary Artery* carries the Blood from that Ventricle into the Lungs, which the *Pulmonary Vein* brings

D 3

from

lies pretty deep in the Skin: And by this they imbibe their proper Nourishment, from the adjacent Humours. Their Extremes also split into two or three Branches, especially if they are very dry, or too long. So that what appears a single Hair to the naked Eye, to the Microscope appears a Brush. They are grey on the Fore-part of the Head, first, particularly about the Temples: The Back-part affords them Nourishment longer. For the same Reason they fall from the Crown of the Head first. Their Thickness depends on the Size of the Pores they issue from: If these are small, the Hair is fine. If the Pores be strait, the Hairs are strait; if oblique or un-equous, the Hairs are curled.

from thence into the left Ventricle. At the upper Side of these Veins, there is added to each Ventricle, a Kind of Purse, called the *Auricle*, which is an hollow Muscle of the same Structure with the Heart, in order to stay the Blood, that it pour not too violently into the Ventricle. Before the Orifices of the Veins of the Heart, there are *triangular* Valves, and *Semilunar* in the Orifices of the Arteries, to hinder the Reflux of the Blood, from the Ventricles into the Veins, and from the Arteries into the Ventricles.

33. The Heart is covered with a fine Membrane; and near the Base of it on the Outside, there is a little Fat, probably designed to facilitate its Motion. It is placed near the Middle of the Breast; only its Cone inclines a little to the Left. It hangs by its Base on Veins and Arteries, communicating with all Parts of the Body. The other Part of it is loose in the *Pericardium*, that it may be the more commodiously constricted and dilated. The *Pericardium* is a Kind of Membrane, that like a Kind of Purse, loosely incloses the Heart. The Shape of it is suited to that of the Heart, and it contains a thin, saltish, reddish Humour, doubtless proceeding from certain Glands, which may be observed on the Inside of it.ⁿ

34. The

ⁿ The Brain has an alternate Contraction and Dilation, answering those of the Heart. It is highly probable, the Weight of the Atmosphere is the Counterpoise to the contractile Force of the Heart. That of the Brain, being not near so strong, does not need so strong a Counterpoise.

In the Basis of the Heart of some Animals, there is a Bone frequently found. Such an one was found in the Heart of Pope *Urban*. Probably it was only the tendons of the Heart ossified.

Wounds of the Heart are not always so immediately mortal, as is generally supposed. A Soldier was brought into one of the Hospitals in *Paris*, with a Wound in the upper Part of the left Breast. He seemed very well for three Days; but on the fourth was taken with a Fever and Difficulty of breathing and died on the tenth. On opening the Body, it was found the Sword had pierced the *Pericardium*, traversed the right Ventricle of the Heart in its lower Part, pierced the *Pericardium* on the opposite Side, and gone thro' the *Diaphragm* and an Inch deep into the Liver.

34. The Heart is placed in the Middle of the *Lungs*, which consists of two Parts, the *Right* and *Left Lobe*. Each of these is divided into two other Lobes; One of these frequently into three, sometimes into four, by Fissures, sometimes deeper, sometimes shallower, running from the interior Margin towards the Back Part. The Lungs are divided into Cells, which are no other than Expansions of the small Branches of the *Trachea* or *Wind-Pipe*. And there is an easy Passage from one Branch into many Cells, and again into it from them all. The upper Part of the *Trachea* opens into the Mouth; The Lower, divided into two Branches, shoots out into various Ramifications, which are termed *Bronchia*. And these little Canals, running on, constitute the Lungs, whose Cells are wonderfully connected together, and intermixed with numberless Branches of Veins and Arteries.

The upper End of the *Trachea* is called the *Larynx*. At the fourth Vertebra of the Back it divides and enters the Lungs. Its Cartilages, ranged at small and equal Distances, are smaller and smaller as they approach the Lungs.

These Cartilages have two Membranes. The External, composed of circular Fibres, covers the whole *Trachea*. That which lines it within, consists of three distinct Membranes, the first woven of two Orders of Fibres, Part Longitudinal, to shorten it, by drawing the Cartilages together, Part circular, to contract them. Both these, together with the external Membrane, assist in breathing, coughing and varying the Tone of Voice. The second Membrane is glandulous;

The Organs which form the Voice of Man, have not been accurately observed by the Antients. As the *Trachea* bears some Resemblance to a Flute, they considered the Voice, according to the Sounds of that Instrument. Mr. *Dodart* was the first who shewed the *Glottis* to be the chief Organ in producing it, and considered it both as a String and Wind-Instrument, far more perfect than any which Art can produce.

The Organs which form the various Voices of other Animals, are likewise worthy of our Attention. Those of each Species have

glandulous; and its Glands opening into the Cavity of the Trachea, separate a Liquor which moistens and defends it from the Acrimony of the Air. The third is a Net-work of Nerves, Veins, and Arteries.

Cutting

peculiar Sounds, whereby they understand each other. Wherein do these Organs resemble ours, and wherein do they differ?

The Human Voice is almost wholly formed by the Glottis, and various Tones are produced by the various Modifications of it. But all these depend on one only, the Separation and Junction of its Lips. This comprehends two Circumstances, the one capital and primitive, the other, a Consequence of it. The first is, That the Lips are more and more bent, from the lowest to the highest Note. The second, that the more they bend, the nearer they draw to each other. It follows from the first, that their Vibrations will be more frequent, as they come nearer the highest Tone, and that the Voice will be exact when they are equally bent, and the Reverse when unequally: which corresponds perfectly well, with the Nature of String-Instruments. It follows from the second, that the higher the Tone, the nearer they draw to each other. And this agrees perfectly with those Wind-Instruments which are governed by Reeds. From these simple and almost imperceptible Variations proceeds the infinite Variety of Sounds.

In most Quadrupeds too the Glottis is the principal Organ of the Voice. So it is in Cats, Sheep, and several others. But many have something more than a Glottis. As Horses, Asses, Mules and Swine. Some of these have also a tendinous Membrane, which concurs in forming the Voice. Others have several Membranes: Others a Kind of Bags, which in some are membranous, and in others bony. Others have both Membranes and Bags. Others lastly have in their Larynx a Kind of Cavity or Drum, which assists them in uttering very strong and long continued Notes.

All Sounds are produced by a swift Succession of Vibrations from the Particles of sonorous Bodies, which agitate the Air. But the Vibrations of the Lips of the Glottis would not suffice to produce the Neighing of a Horse. This begins by more or less acute interrupted Tones, accompanied by Quaverings, and ends by Tones more or less grave, which is performed by Jirks. This second Part is done by the Lips of the Glottis: The other chiefly by a small, elastic Membrane. This is tendinous, very thin, of a triangular Figure, and lies flat on each Extremity of the Lips of the Glottis. As it adheres but loosely to these, it can easily flutter up and down: And it is the Play of the Membrane up and down, which produces the acute Sounds of Neighing. These are more or less acute, as the Membrane is more or less thin, and its Adhesion more or less slack. The grave Sounds that conclude the Neighing, are excited by the Flutterings of the thick Strings which form the Lips of the Glottis.

Cutting the Trachea was long reputed mortal. But it is now usual to open it in dangerous Quinsies. This Physicians were at first encouraged to do, from the Case of a *Cornish* Gentleman, who had his Wind-Pipe quite cut through, and yet was cured and lived several Years after.

35. In order to the Admission and Expulsion of the Air by the Lungs, it is necessary the Breast should be contracted and dilated. This End is served by the bony Part of the *Thorax*, the *intercostal Muscles*, and the *Diaphragm*, a broad, muscular Part, reaching cross the Breast, and dividing the Middle from the lower Cavity. It runs obliquely from the *Sternum* and Ribs before, to the Vertebrae of the Loins behind.

36. The

The hoarse Sound of the Asses Voice is not so much produced by the Lips of the Glottis, as by a tendinous Part which adheres loosely on the Aperture of a Kind of Drum, situate under the Extremity of the Lips of the Glottis: Above which are also found two large and thick Bags, one on the Right, the other on the Left. Each of these has a roundish Aperture, cut much like the Stopples of an Organ.

Such are the Organs which form this amazing Sound. A Kind of Drum is the principal: And the two Bags above the Lips of the Glottis, are the main Auxiliaries: While those Lips, as plain Experiments shew, contribute very little thereto. The Mules Voice much resembles that of his Sire, and is formed by much the same Organs: The Drum of so singular a Composition, being found in Mules also.

There is another Animal which affords us a particular Disposition of the vocal Organs. This is the Hog: whose shrill Cries are more insupportable than his usual Grunting. Yet neither are these excited by the Lips of the Glottis, but by the fluttering of two large membranous Bags: situated on each Side, above the Lips of the Glottis. What is most remarkable is, that each Lip is cloven, almost its whole Length. By this Cleft each Lip has a Communication with the Bag belonging to it. And the Motions of these Bags produce most of the Sounds peculiar to this Animal.

Tho' the Voice of Birds bears a nearer Resemblance to ours than that of Quadrupeds, yet their Organs have far less Resemblance to ours, and contain a greater Number of Singularities. They, like us, have a Glottis at the Top of the Trachea: But they have another at the Bottom of it, which much contributes both to the strengthening and modifying of their Voice. These have different Membranes more or less fine, more or less bent, and in a Variety of Positions. In some Birds, as in Geese, there are four of these, figured and disposed like the Reeds in Hautboys.

36. The whole Thorax is covered on the Inside with a firm, white Membrane, called the *Pleura*. It is double throughout, consisting of two Folds, the innermost whereof has a smooth Surface, that it may not hurt the tender Substance of the Lungs, the Surface of the Outer is rough and uneven. From the *Pleura* rises the *Mediastinum*, which is a doubled Membrane, that divides the Lungs and the Cavity of the Thorax lengthways into two Parts.

37. On the slightest Observation we cannot but acknowledge, the consummate Wisdom wherewith the *External Parts* of the middle Cavity are formed, for Beauty as well as for the Defence of the Internal. This is commodiously connected with the Head by the Neck. The *Breast*, or Forepart of the Thorax, which begins at the Throat, and ends at the *Sternum*, or Breast-bone, is an admirable Guard to the noblest Parts. To the same End serve the *Shoulder-blades* and the *Back-bone*, as well as to support the whole Fabric.

The *Breasts* consist of numberless oval Glands, intermixed with globular Vessels of Fat. Their Ducts as they approach the Nipple unite together, till they form eight or more small Pipes, communicating with each other by cross Canals, which are of great Use, when some of them happen to be obstructed. These Tubes are in some Parts narrower, in some wider, so as to form Cells, which hinder the Efflux of the Milk. The *Paps* consist chiefly of the Concurrence of these Tubes, but with a glandulous Substance intermixt. There are likewise joined herewith Abundance of Fibres, from the external Teguments of the Breasts, by Means of which the Tubes are constricted, and the Motion of the Milk is modified.

In Virgins the Glands of the Breasts are so contracted, that no Blood can enter them. But when the Womb swells with the Fetus, and compresses the descending Trunk of the great Artery, the Blood forces its Way into them. They admit thicker and thicker Serum, till after the Birth, they run with a thick Milk.

It is more difficult to account for the Milk, which some Men have in considerable Plenty. Thus in the Year

Year 1684 a Countryman called *Billardino di Billo*, living in a Village near *Nocera* in *Umbria*, when his Wife was dead, took the Child, and putting the Nipples of his Breasts into its Mouth, invited it to suck, which the Infant did, and after several Times drawing, fetched some Milk. After a while it brought down the Milk so plentifully, as to nourish it for many Months, till it was weaned.

38. In the lower Cavity first occurs the *Stomach* with the *Oesophagus* or *Gullet*, which reaches to it from the Mouth. The Inner Coat of the Stomach is *Nervous*. The second is *Villous*, or as it were hairy, in which are innumerable fine Blood-vessels, which are supposed to yield a Liquid that helps to dissolve the Nutrient. The inner Surface of the Stomach has many Wrinkles or Folds, which hinder its Contents from passing out too soon. It has two Orifices, the *Left* and the *Right*. The Left is a Continuation of the Gullet, and descends almost perpendicularly, which hinders the food from easily regurgitating. It opens for the Descent of the Food, and closes again, by the Contraction of its Fibres. The right Orifice, called the *Pylorus*, transmits the digested Food to the *Intestines*. It is narrower than the other, as being designed to transmit nothing, till it is reduced to a Kind of Liquid. And it goes by a long and oblique Descent into the *Duodenum*, that the Chyle may not pass out, either too swiftly or too slowly.

39. The *Intestines* are a Continuation of the Alimentary Tube from the *Pylorus*, wound together in various Wreaths, yet without Confusion, and to keep them in their Situation, fastened together by the *Mesentery*, a strong Membrane, which fastens them also to the Back. The Intestinal Duct is really but one; but because the Parts of it differ in Figure and Use, the upper Part of it, divided into the *Duodenum*, *Iejunum* and *Ileon*, is termed the *small Guts*; the lower Part, divided into the *Cæcum*, *Colon* and *Rectum*, is called the *great Guts*. All these are full of Turnings and Windings, especially the small, that the more subtle Part of the Chyle, both thro' the Length and Narrowness of the Passage, and the Agitation of the Intestines, may enter the *Lacteal Vens*, and pass from thence into the *Receptacle of the Chyle*.

When

When the Intestines are separated from the Mesentery, they are usually six Times as long as the Man. They have all a Kind of vermicular Motion, called the *Peristaltic Motion* from the Stomach downwards; and are lubricated with much Fat, especially the great ones, whose Surface being more uneven, and their Contents less fluid, they need somewhat more to make them slide easy.

The Duodenum, (so called because it is usually ten or twelve Inches long) receives the Gall and Pancreatic Juice, which are here mixt with the Chyle. The Jejunum is so termed, because it is generally more empty than the Rest. This may be occasioned partly by its Capacity, which gives a free Passage to its Contents; partly to its Irritation thro' the Bile, which falls in a little above it. It takes up almost the whole umbilical Region, and is usually twelve or thirteen Hands long. The Ileon, situate below the Navel, fills the Illia with its numerous Convolutions. It is much the longest of all the Intestines, generally one and twenty Hands long. In both this and the Jejunum the inner Coat is much wrinkled, and lies in loose Folds. They are formed (as the Folds in the Stomach) only by the inner Coat being larger than the outer.

The first of the great Guts, called the *Cæcum*, is laterally inserted at the upper End of the Colon. It is not perforated at the other End, but hangs to it, like the Finger of a Glove, and is three or four Inches long. In new-born Children and in Beasts it is found full of Excrements; but in Adults it frequently hangs like a Worm. In a Fætus it is doubtless a Receptacle of the Fæces, during the Time it does not discharge by stool. And may it not occasionally serve the same End in Adults? Perhaps in those Animals wherein it is very large, it may likewise serve as a Kind of second Stomach. But it is not absolutely necessary. The *Cæcum* of a Dog has been cut out, without any perceivable Prejudice.

The Colon is the largest of the great Guts. It runs in various Circumvolutions from the *Cæcum* to the Rectum. It has many Cavities, formed by two Ligaments, running

running on each Side of it, opposite to each other the whole Length, and as it were guiding it at certain Distances. The Rectum, which reaches from the *Os Sacrum* to the *Anus*, is usually about an Hand and an half long.

40. The *Lacteal Veins*, which are of a whitish Colour, are in all the Intestines, small and great, and receive the Chyle by imperceptible Passages, throughout the whole Canal. And for this End the Food remains so long in the Intestines, and is carried thro' various Windings, that whatsoever of Nourishment it contains, may be exprest before it leaves the Body.

41. The Intestines are covered with the *Omentum* or *Cawl*, which is contained within the *Peritoneum*, a very thin, soft, double Membrane, and wholly consists of little Bags of Fat. Its Use is, to keep the Intestines warm; to promote their peristaltic Motion by lubricating them with its oily Substance: By following them in their Doublings and Windings, to serve them as a Bolster to slide upon, and by filling up their Hollows, to prevent their being too much distended by flatulencies; yet giving Way to them when filled with Aliments.

Under the Stomach behind lies the *Pancreas*, (extended towards the Spleen) which transmits to the Intestines a Liquor of the Nature of Spitile, helping to dissolve the Food.

42. Under the Diaphragm, on the right Side, lies the *Liver*, whence it extends over the Right Part of the Stomach, below the Sternum, toward the Left, growing gradually smaller, that it may not hinder the Distention of the Stomach. It consists partly of Gall-Ducts partly of fine Ramifications of the *Vena Portæ*. The Blood contained in these, deposits oily Particles in the Ducts, and then returns, chiefly thro' the *Vena Cava*, to the Heart. It is thus the *Bile* is secreted, for which Purpose the *Gall-bladder* also is designed. This both receives and retains the Bile, by which Delay the Power of it is greatly heightened. Part of the Bile is conveyed to the Intestines by the *Hepatic Duct*, which pours it into the *Ductus Cholecysticus*. Part goes first into the Gall-bladder, thence into

the Ductus Choledochus, and then into the Duodenum.

The principal Use of the Bile is, to absterge and stimulate the Intestines, to assimilate crude Things to Things concocted, to bruise and blunt sharp and saline Particles, to divide those that are coagulated: To excite Appetite, to open the Passages for the Chyle, and where need is, act the Part of a Ferment.

43. The *Spleen* is an elegant Net-work of numberless Vessels, inclosed in a double Membrane. It is placed on the Left Side, between the Short Ribs and the Stomach. Some suppose it to secrete a peculiar Juice, which passes with the Blood thro' the Vena Portæ. Others imagine it to be a Kind of Reservoir, wherein on extraordinary Occasions, that Blood may be received, which would otherwise oppress the Viscera and disturb the Animal Functions.

44. On the Muscles of the Loins on each Side lie the *Kidneys*, to separate from the Blood that Part of the Serum which is superfluous, and would be hurtful were it retained in the Habit. This is carried by the *Ureters* into the Bladder, which is placed in the lowest Part of the Belly. What remains of the Blood is conveyed to the Heart by the Veins and Lymphatic Vessels.

The *Bladder* is composed of Three Coats: The First is an Extension of the *Peritoneum*; the Second consists of Muscular Fibres; the Third is both glandulous and nervous, and full of Wrinkles, that it may be capable of Contraction and Dilatation. Its Glands separate a slimy Matter, which defends the Bladder from the Acrimony of the Urine. The involuntary Emission of this is prevented, by a small Muscle which goes round the neck of the Bladder.

45. We proceed to the *Limbs*. The *Hand* (physically speaking) is divided, into the *Arm*, the *Cubit*, and the *Hand*, properly so called. In this there are Twelve Bones, beside Fifteen in the Fingers, all oblong, slender, hollow, and so fitly joined together by Ligaments, so wonderfully provided with various Muscles, adapted to so many different Motions, that

the Hand alone gives us an abundant Argument of the admirable Wisdom of God.

46. The *Thigh* consists of one Bone, the largest and longest in the whole Body. It is a little crooked, bending forward before, that there may be more Room for the Muscles. The Bones of the *Leg* are two, distant from each other in the Middle, but joined together at each End. They are nearly of the same Length, but the Inner is much thicker than the Outer. The Bones of the *Foot* are twelve, beside fourteen in the *Toes*; which like those in the Hands, are most aptly connected by Ligaments, and fitted with Muscles of various Kinds, serving for equally various Motions.

47. Thus far we have spoken concerning the *Solid Parts* of the Body. Among the *Fluid* are usually reckoned *The Animal Spirits*, supposed to be secreted in the Brain, to flow thro' the Nerves, and to be the Instruments of Sense and Motion. 2

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48. Of

"But are the Nerves in general hollow Canals, which contain a circulating Fluid? Or are they solid Threads, which being highly elastic, vibrate variously to Occasion various Sensations?" The latter Supposition is wholly overthrown, by the Phenomena of wounded Nerves. A Nerve cut asunder does not retract its divided Extremities, but becomes rather longer, extruding its Medulla into a round Tubercle. Again, were it elastic, it should be composed of hard Fibres, having their Extremities fixt to some firm Bodies: Since Strings otherwise constituted and disposed, have no Elasticity. But it is evident, all Nerves are soft at their Origin, as well as void of Tension: And some soft in every Part, as the Olfactory Nerve, and the soft Portion of the Auditory Nerve. Yea, they all grow soft in the Viscera, the Muscles and the Sensories, before they exert their Functions. Besides, some Nerves are so situate, that they cannot vibrate, as those of the Heart, which are fastened to the great Vessels and the Pericardium. Further, the Influence of an irritated Nerve is never propagated upwards; whereas an elastic Chord, communicates its Tremors to both Ends from the Point of Percussion. Hence it is plain, the Nerves do not Act by their Spring, but by the Motion of their proper Fluid. The extreme Smallness of these Canals, which no Microscope can reach, is no valid Objection to this: Neither our Inability to discern that Fluid. This only proves the Imperfection of our Senses.

"But what is this Fluid?" Who can tell? We may very probably Conjecture, it consists of the same Principles with the Circulating Fluids from which it seems to be derived, and with the per-

48. Of the other Fluids, some serve to prepare the Chyle; Some to thin the Blood and preserve it from Putrefaction. Others only remain till they can be thrown out of the Body, as being useless and superfluous. All of these, but the Chyle, arise from the Blood, being secreted from it by proper Glands. But as to the Manner of Secretion, after all the most accurate and laborious Enquiries, it still remains absolutely uncertain, and every one abounds in his own Sense. Some believe it depends, on the *Suitableness* of the Fluid secreted, to the Shape of the secreting Pores. Some lay the Stress rather on the various Size and *Diameters* of those Pores: Others on this, That the constituent Particles, suppose of the Bile, from their peculiar Proportion, Texture and Figure, may be more easily united to each other, than to the Particles of Lymph, or any other Fluid.

49. The chief of all the Fluids in our Body, and the Fountain of Life is the *Blood*. It consists of a watry *Serum*, *fibrous Particles* and *red Globules*, which last are scarce a twelfth Part of it. It is generated thus. The Meat and Drink being digested into Chyle, passes from the Intestines, thro' the Lacteal Veins and the Thoracic Duct into the left Subclavian Vein, and thence into the Vena Cava, where it mixes with the Blood, and then circulates with it, till it is wholly assimilated.

Blood fresh drawn appears to the naked Eye uniform and homogeneous. But when cold, it separates into two Parts, the one red and fibrous, which clots together, the other thin and transparent, called the *Serum*, in which the former swims. The Serum is in Bulk three fourths of the Blood, in weight fifteen Seventeenths.

A Red Globule is computed to be 25000 Times smaller than the smallest Grain of Sand.

Some

vous Fibrils which we suppose it is designed to nourish and Repair. But it may likewise consist, and perhaps chiefly, of some subtle Fire or Ether, diffused thro' the whole System of Nature, and acting by Laws unknown to us.

Some suppose the Heat of the Blood may arise from the Action of the Heart, and the Re-action of the Aorta. For the Blood driven by the Heart obliquely against the Sides of the Aorta, violently presses them and is by the Elasticity of this Vessel pressed back again. Every Particle of it therefore acquires every Moment a new Motion and Rotation. Hence follows a perpetual Attrition, Attenuation and Assimilation of all its Parts. And hence they think the Mass derives its Heat as well as Fluidity. ⁹

But to what Cause is its Colour owing? *Borelli* took some of the red Part, and washing it frequently in Water, found it separable into a viscous, slippery Substance, consisting of colourless Fibres, which rose and gathered into a Scum on the Top of the Water, and a deep-red Powder, which precipitated plentifully to the Bottom. Hence it appears, that the Redness of the Blood springs from red-tinging Particles, as in the Case of Dying.

However this red Colour, though generally found in the Blood of Land Animals, is not absolutely necessary, there being some Species, whose Blood is white or limpid. Nay *Dr. Drake* let out of the Median Vein of a Man, a pure, white Blood, like Milk, which when cold, did not separate into two Parts, as the Red usually does. Nor yet did it yield any Skim or Cream, neither turn sour as Milk uses to do. *Dr. Beal* gives an Instance of the same Kind; and *Dr. Lower* relates one as strange. A Person bled at the Nose, till at length the Broth he drank flowed out very little altered.

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50. These

⁹ But others deny, that the Motion of Fluids generates any Heat. The Truth is, this is one of the ten thousand Secrets, which the Mind of Man cannot penetrate.

It is amazing to see, how careful Providence has been, to prevent the Blood's running into Concretions, which might destroy Life; by the very Dispositions of the Vessels it is to run thro'. These are so contrived, as to cause the Globules to come together with a brisk Collision. The Arteries which convey the Blood from the Heart to the Extremities, continually lessen, as they recede from their Source; in Consequence of which, the Globules of Blood must

50. These are the Parts, of which this wonderful Machine is composed, which the Chymists say, consists of four Sorts of Matter, Earth, Water, Salt, and Sulphur, the Particles of which being variously mixt together, constitute larger Particles of different Kinds; out of which, more loosely or closely connected, all the Parts of the Body, Solid or Fluid are composed.

But this is far from being an accurate Account. For what are Salt and Sulphur but Species of Earth? May not we then much more properly say, with the Antients, That the Body is chiefly composed of Earth and Water, yet cannot enjoy even Animal Life, unless Air and Fire also be wrought into its Frame? So that at whatsoever Time, it is deprived either of Air or Fire, it is an useless, lifeless Clod. And yet the Manner how these are so intimately mixt, both with our Fluid and Solid Parts as much exceeds our Comprehension, as the manner how the Soul is united to its House of Clay.

It remains only, to add some Reflections on the Wisdom of God, displayed in the Structure of the Human Body. And how eminently is this displayed, First, In the *Situation* of its several Parts and Members? They are situated most conveniently for Use, for Ornament, and for mutual Assistance. 1. For Use. The principal Senses are placed in the Head, as Centinels in a Watch-tower. How could the Eyes have been more commodiously fixt, for the Guidance of the whole Body? The Ears likewise, made for the Reception of Sounds, which naturally move upward, are rightly placed in the uppermost Parts of the Body: And so are the Nostrils, as all Odours ascend. Again: How could the Hands have been more conveniently placed

rush with force against one another, as they are driven on impetuously. And the Veins which bring it back from the Extremities to the Heart, enlarging all the Way as they go on, while the Streams of several continually run into one, each of these Ingresses causes new Commotions, capable tho' not of dissolving that natural Connexion of the red and serous Particles, yet of preventing any preternatural Concretions or Coagulations.

placed, for all Sorts of Exercises? Or the Heart, to dispense Life and Heat to the whole Body? Or the Sinks of the Body, than in the most remote Parts of it? 2. For Ornament. Not to descend to Particulars, what could be better contrived, than that those Members which are Pairs should be of equal Length, and just answer one another on each Side? 3. For mutual Assistance. So the Eye stands most conveniently to guide the Hand, and the Hand to defend the Eye. The same may be said of the other Parts: they are all so placed, as to direct or help each other. This will clearly appear, if you suppose the Position of any of them to be changed. Had our Arms been bent backward, what Direction could our Eyes have afforded us in Working? Or how could we even have fed ourselves? Nay, had one Arm bent backward, and the other forward, half the Use of them had been lost; for one could not have assisted the other in any Action.

How is his Wisdom displayed, Secondly, in the ample Provision made for the Security of the principal Parts? These are 1. The Heart, the Fountain of Life. This lies in the Center of the Trunk of the Body, covered with its own Membrane, the Pericardium, lodged within the soft Bed of the Lungs, incompass'd round with a double Fence, both of thick Muscles and Skins, and of firm Ribs and Bones: Beside the Arms conveniently placed, to ward off any Violence: 2. The Brain, the Principle of all Sense and Motion, is surrounded with so strong a Defence, that it must be a mighty Force indeed, which is able to injure it. The Skull is so hard, thick and ought that 'tis almost as firm as an Helmet of Iron. This is covered with Skin and Hair, which both keep it warm, and soften the violence of a Stroke. Yet more, a thick and tough Membrane hangs loose about it, which often saves it, even when the Skull is broke. And lastly, a fine Membrane closely adheres, to keep it from quashing and shaking.

How is it displayed, Thirdly, in the abundant Provision that is made against evil Accidents and Inconveniences?

veniences? To this end, 1. The Members which are of eminent Use are in Pairs: We have two Eyes, Ears, Nostrils, Hands; two Feet, two Breasts, two Kidneys; that if one should be rendered useless, the other might serve us tolerably well: Whereas had a Man but one Hand or Eye, if that were gone, all were gone. 2. All the Vessels have many Ramifications, which send forth Twigs to the neighbouring Vessels: So that if one Branch be cut or obstructed, its Want may be supplied, by the Twigs from the neighbouring Vessels. 3. Many Ways are provided to evacuate, whatever might be hurtful to us. If any thing oppresses the Head, it can free itself by Sneezing; if the Lungs, they can cast it off by Coughing. If any thing burden the Stomach, it can contract itself, and throw it up by Vomit. Beside these Evacuations, there are Siege, Urine, Sweat, and Hemorrhagies of various Kinds. 4. Whereas Sleep is necessary for us in many Respects. Nature has provided, that tho' we lie long on one Side, we should feel no Uneasiness while we sleep, no, nor when we awake. One would think, the whole weight of the Body pressing the Muscles on which we lie, would be very burdensome. And we find by Experience, so it is, when we lie long awake in the Night. Probably this Provision is made, by an Inflation of the Muscles, making them soft, and yet renitent, like Pillows. That they are inflated during Sleep, appears to the very Eye, in the Faces of Children; and from the common Experiment, that if we sleep in our Cloaths, we must loosen our Garters and others Ligatures. Otherwise we find Uneasiness in those Parts. 5. Because Sleep is inconsistent with the Sense of Pain, therefore during Rest, those Nerves which convey the Motions to the Brain, which excite the Sense of Pain, are obstructed. "This I myself, says Mr. Ray, have often experienced, since I have had Sores on my Legs. Waking suddenly, I find myself at perfect Ease for a while. Then the Pain by Degrees returns."

It is displayed, Fourthly, In the *Multitude of Intentions* God hath in the Formation of the several Parts, and the *Multitude of Qualifications* they require, to fit them for their several Uses. *Galen* observes, "that there are in an human Body, above six hundred Muscles. And there are at least ten several Intentions in each, and as many Qualifications needful: So that about the Muscles alone, no less than 6000 Ends are to be attended to. The Bones are reckoned to be 284. The distinct Intentions in each of these are above Forty: In all, about an hundred Thousand. And thus it is in Proportion, with all the other Parts, the Skin, Ligaments, Veins, Arteries, Nerves, Glands, Humors: But more especially with the Members of the Body, which as to the Multitude of Intentions and Qualifications, far exceed the similar Parts. And should one of these Qualifications fail, great Inconvenience would ensue."

It is displayed, Fifthly, in the *Stature* of Man, so admirably well adapted to the Circumstances of his Existence. Had Man been only a Foot or two high, he had been quite disproportioned to every Thing round about him. Had he been much larger, he could not well have been supplied with Food: All the edible Animals would not have sufficed. And had they too been proportionably larger, the Surface of the Earth would not have sufficed to feed them.

It is however a common Opinion, and has been so ever since old *Homer's* Time, that the People in the early Ages of the World, were much larger than us. And it is true, we read of some Men, of a surprizing Stature. But they were even then esteemed Giants. The ordinary Stature of Men, is probably just the same now, as it was at the beginning. This may be gathered from the Monuments still remaining, particularly the Pyramids of *Egypt*. The Cavities for Bodies now visible herein, are little larger than our ordinary Coffins: Likewise from several embalmed Bodies taken out of them it appears, that Men are of the same Stature now, that they were when those Pyramids were built, which is at least three thousand Years

Years ago.

Eighteen hundred Years ago the Emperor *Augustus* was five Foot, seven Inches high, Queen *Elizabeth* was taller by two Inches, being five Foot, nine.

I cannot better conclude this Chapter than by an Extract from the late pious and ingenious Mr. *Hervey*, which may serve for a Recapitulation of what has been said, as well as an Improvement of it.

“ Let us begin with the less adorned, but more solid Parts, those which support, and which contain the Rest. First, you have a System of *Bones*, cast in a Variety of Moulds, in a Variety of Sizes: All strong, that they may bear up the Machine, yet light, that they may not weigh us down: Bored with an inward Cavity, to contain the moistning Marrow, and perforated with fine Ducts, to admit the nourishing Vessels. Insensible themselves, they are covered with a Membrane, exquisitely sensible, which warns them of, and secures them from the Annoyance of any hurtful Friction; and also preserves the Muscles from being fretted in their Action, by the hard and rough Substance of the Bone. They are largest at the Extremities; that they may be joined more firmly, and not so easily dislocated. The Manner of their Articulation is truly admirable and remarkably various: yet never varied without demonstrating some wise Design, and answering some valuable End. Frequently when two are united, the one is nicely rounded and capped with a smooth Substance; the other is scooped into an Hollow of the same Dimensions to receive it. And both are lubricated with an unctuous Fluid, to facilitate the Rotation.

The Feet compose the firmest Pedestal; infinitely beyond all that Statuary can accomplish, capable of altering its Form, and extending its Size, as different Circumstances require. They likewise contain a set of the nicest Springs, which help to place the Body in a Variety of Attitudes, and qualify it for a Multiplicity of Motions. The undermost Part of the Heel, and the Extremity of the Sole, are shod with a tough, insensible Substance: A Kind of natural Sandal, which never wears

wears out, never wants Repair : and which prevents an undue Compression of the Vessels, by the Weight of the Body. The *Legs* and *Thighs* are like stately Columns, so articulated, that they are commodious for Walking, and yet do not obstruct the easy Posture of sitting. The Legs swell out toward the top with a gentle Projection, and are neatly wrought off toward the Bottom : A Variation which lessens their Bulk, while it increases their Beauty.

The *Ribs*, turned into a regular Arch, are gently movable, for the Act of Respiration. They form a safe Lodgment for the Lungs and Heart, some of the most important Organs of Life. The *Backbone* is designed, not only to strengthen the Body, and sustain its most capacious Store-rooms, but also to bring down the Continuation of the Brain, usually termed the *Spinal Marrow*. It both conveys and guards this *silver Cord*, as Solomon terms it, and by commodious Outlets transmits it to all Parts. Had it been only strait and hollow, it might have served these Purposes. But then the Loins must have been inflexible : To avoid which, it consists of very short Bones, knit together by Cartilages. This Peculiarity of Structure gives it the Pliancy of an Osier, with the Firmness of an Oak. By this Means it is capable of various Inflections, without bruising the soft Marrow, or diminishing that Strength which is necessary to support all the upper Stories. Such a Formation in any other of the Solids, must have occasioned great Inconvenience. Here it is unspeakably useful, a Master-piece of creating Skill.

The *Arms* are exactly proportioned to each other, to preserve the Equilibrium of the Structure. These being the Guards that defend, and the Ministers that serve the whole Body, are fitted for the most diversified and extensive Operations: Firm with Bone, yet not weighty with Flesh, and capable of performing all useful Motions. They bend inwards and turn outwards; they move upward or downward. They wheel about in whatever Direction we please. To these are added the *Hands*, terminated by the *Fingers*, not of the same Length,

Length, nor of equal Bigness, but in both Respects different, which gives the more Beauty, and far greater Usefulness. Were they all Flesh, they would be weak: Were they one entire Bone, they would be utterly inflexible: But consisting of various little Bones and Muscles, what Shape can they not assume? Being placed at the End of the Arm, the Sphere of their Actions is exceedingly enlarged. Their Extremities are an Assemblage of fine tendinous Fibres, acutely sensible: Which notwithstanding are destined to almost incessant Employ, and frequently among rugged Objects. For this Reason they are overlaid with Nails which preserve them from any Impressions.

In the Hand we have a Case of the finest Instruments. To these we owe those beautiful Statues, this melodious Trumpet. By the Strength of the Hand the tallest Firs fall, and the largest Oaks descend from the Mountains. Fashioned by the Hand they are a floating Warehouse, and carry the Productions of Art and Nature from *Britain to Japan*.

The Hand is the original and universal Sceptre, which not only represents, but ascertains our Dominion over all the Elements and over every Creature. Though we have not the Strength of the Horse, the Swiftness of the Greyhound, or the quick Scent of the Spaniel, yet directed by the Understanding, and enabled by the Hand, we can as it were make them all our own. These short Hands have found a Way, to penetrate the Bowels of the Earth, to touch the Bottom of the Sea. These feeble Hands can manage the Wings of the Wind, arm themselves with the Violence of Fire, and press into their Service the forcible Impetuosity of Water. How greatly then are we indebted to our wise Creator, for this distinguishing, this invaluable Member?

Above all is the *Head*, for the Residence of the Brain, ample to receive, and firm to defend it. It has a Communication with all, even the remotest Parts; has Outlets, for dispatching Couriers to all Quarters, and Avenues for receiving speedy Intelligence, on all needful Occasions. It has Lodgments wherein to post Centinels,

for

for various Offices: To expedite whose Operations, the whole turns on a curious Pivot, nicely contrived to afford the largest and freest Circumvolutions.

This is screened from Heat, defended from Cold, and at the same Time beautified by the *Hair*: A Decoration so delicate, as no Art can supply, so perfectly light, as no Way to incumber the Wearer.

While other Animals are prone in their Aspect, the Attitude of Man is *erect*, which is by far the most graceful, and bespeaks Superiority. It is by far the most commodious, for Prosecution of all our Extensive Designs. It is likewise safest, less exposed to Dangers, and better contrived to repel or avoid them. Does it not also remind us of our noble Original and our sublime End? Our Original, which was the Breath of the Almighty: Our End, which was the Enjoyment of Him in Glory?

Thus much for the *Rafters* and *Beams* of the House. Let us now survey the Lodgings within. Here are *Ligaments*, a tough and strong Arrangement of Fibres, to unite the several Parts, and render what would otherwise be an unwieldy Jumble, a well-compacted and self-manageable System: *Membranes*, thin and flexile Tunicles, to inwrap the fleshy Parts, to connect some, and form a Separation between others: *Arteries*, the Rivers of our little World, that striking out as they go, into numberless small Canals, visit every Street, yea every Apartment in the vital City. These being wide at first, and growing narrower and narrower, check the Rapidity of the Blood. This thrown from the Heart, dilates the Arteries, and their own elastic Force contracts them: by which Means they vibrate against the Finger, and much assist both in the Discovery and Cure of Diseases. The larger Arteries, wherever the Blood is forced to bend, are situate on the bending Side; lest being stretched to an improper Length, the Circulation should be retarded. They are not, like several of the Veins, near the Surface, but placed at a proper Depth. And hereby they are more secure from External Injuries. In those Parts which are most liable to Pressure,

an admirable Expedient takes Place. The Arteries *inogulate* with each other: breaking into a new Tract, they fetch a little Circuit, and afterwards return into the main Road. So that if any Thing block up or straiten the direct Passage, the Current by diverting to this New Channel, eludes the Impediment, flows on, and soon regains its wonted Course.

The *Veins* receive the Blood from the Arteries, and re-convey it to the Heart. The Pressure of the Blood is not near so forcible in these, as in the Arteries. Therefore their Texture is considerably lighter. Such an exact Economist is Nature, amidst all her Liberality! In many of these Canals, the Current, tho' widening continually, is obliged to push its Way against the perpendicular: Hereby it is exposed to the Danger of falling back and overloading the Vessels. To prevent this, *Valves* are interposed at proper Distances, which are no Hindrance to the regular Passage, but prevent the Reflux, and facilitate the Passage of the Blood to the grand Receptacle. But these Valves are only where the Blood is constrained to climb: Where the Ascent ceases, they cease also.

Here are *Glands* to filtrate the passing Fluids, each of which is an Assemblage of Vessels, complicated with seeming Confusion, but with perfect Regularity. Each forms a Secretion far more curious than the most admired Operations of Chymistry: *Muscles*, composed of the finest Fibres, yet endued with incredible Strength, fashioned after a Variety of Patterns, but all in the highest Taste for Elegance and Conveniency. These are the Instruments of Motion, and at the Command of the Will, execute their Functions quick as Lightning: *Nerves*, surprizingly Minute, which set the Muscles at Work, diffuse the Power of Sensation thro' the Body, and upon any Impression from without, give all needful Intelligence to the Soul: *Vesicles*, distended with an unctuous Matter, in some Places compose a soft Cushion; as in the Calf of the Leg, whose large Muscles, mixt with Fat are of singular Service to those important Bones. This flanks
and

and fortifies them, like a strong Bastion, supports and cherishes them, like a soft Pillow. In other Places they fill up the Vacuities, and smooth the Inequalities of the Flesh: Inwardly they supply the Machine for Motion; Outwardly they render it smooth and graceful.

The *Skin*, like a curious Surtout, covers the whole, formed of the most delicate Net-work, whose Meshes are minute, and whose Threads are multiplied, even to a Prodigy: The Meshes are so minute, that nothing passes them which is discernible by the Eye; tho' they discharge every Moment Myriads and Myriads of superfluous Incumbrances. The Threads are so multiplied, that neither the Point of the smallest Needle, nor the infinitely finer Lance of a Gnat, can pierce any Part, without drawing Blood, and causing an uneasy Sensation. Consequently, without wounding by so small a Puncture, both a Nerve and a Vein!

But a Course of incessant Action must exhaust the Solids and waste the Fluids, and unless both are properly recruited, in a short Time destroy the Machine. For this Reason it is furnished with the *Organs*, and endued with the *Powers of Nutrition*: *Teeth*, the foremost, thin and sharp, to bite asunder the Food; The hindermost, broad and strong, indented with small Cavities, the better to grind in Pieces what is transmitted to them. But in Children, the formation of Teeth is postponed till they have Occasion for them.

Were the Teeth, like other Bones, covered with the Periosteum, Chewing would give much Pain. Were they quite naked, they would soon decay and perish. To guard against both, they are overlaid with a neat *Enamel*, harder than the Bone itself; which gives no Pain in Chewing, and yet secures them from various Injuries.

The *Lips* prevent the Food from slipping out of the Mouth, and assisted by the Tongue, return it to the Grinders. While they do this in Concert with the Cheeks, they squeeze a thin Liquor from the adjacent Glands. This moistens the Food and prepares it for Digestion. When the Mouth is inactive these

are nearly closed. But when we speak or eat, their Moisture being then Necessary, is express as Need requires.

But the Food could not descend merely by its own Weight, thro' a narrow and clammy Passage into the Stomach. Therefore to Effect this, Muscles both *strait* and *circular* are provided. The former enlarge the Cavity, and give an easy Admittance. The latter, closing behind the descending Aliment, press it downward. But before the Food enters the Gullet, it must of Necessity pass over the Orifice of the Windpipe: Whence it is in Danger of falling upon the Lungs, which might Occasion instant Death. To obviate this, a *moveable Lid* is placed, which when the smallest Particle advances, is pulled down and shut close, but as soon as it is swallowed, is let loose and stands open. Thus the important Pass is always made sure against any noxious Approaches; yet always left free for the Air and open for Respiration.

The Food descending into the *Stomach* is not yet ready for the Bowels. Therefore that great Receiver is strong to bear, and proper to detain it, till it is wrought into the smoothest Pulp imaginable. From hence it is discharged by a gentle Force, and passes gradually into the Intestines.

Near the Entrance waits the *Gall-Bladder*, ready to pour its salutary Juice upon the Aliment, which dissolves any Thing viscid, scours the Intestines, and keeps all the fine Apertures clear. This Bag, as the Stomach fills, is prest thereby, and then only discharges its Contents. It is also furnished with a Valve of a very peculiar, namely, of a Spiral Form; thro' which the deterfive Liquid cannot hastily pour, but must gently ooze. Admirable Construction! Which without any Care of ours, gives the needful Supply, and no more.

The Nutriment then pursues its Way, thro' the Mazes of the *Intestines*: Which by a *Worm-like Motion* protrude it and Force its small Particles into the *Lacteal Vessels*. These are a Series of the finest Strainers,

ers, ranged in countless Multitudes all along the Sides of the winding Passage. Had this been strait or short, the Food could not have resigned a sufficient Quantity of its nourishing Particles. Therefore it is artfully convolved and greatly extended, that whatever passes may be sifted thoroughly. As the Aliment proceeds, it is more and more drained of its nutritious Juices. In Consequence of this, it would become hard and pain the tender Parts, but that Glands are posted in proper Places, to discharge a lubricating Fluid. These are smaller or fewer near the Stomach, because there the Aliment is moist enough: Whereas in the Bowels remote from the Stomach, they are either multiplied or enlarged.

The Chyle drawn off by the Lacteals is carried thro' Millions of Dusts, too fine even for the Microscope to discover. To this it is owing, that Nothing enters the Blood, but what is capable of passing thro' the finest Vessels. It is then lodged in several commodious Cells (the Glands of the *Mesentery*) and there mixt with a thin, diluting Lymph, which makes it more apt to flow. Hence it is conveyed to the *Common Receptacle*, and mounts thro' a perpendicular Tube into the *Left Subclavian Vein*. This Tube lies contiguous to the *Great Artery*, whose strong Pulsation drives on the Fluid, and enables it to ascend and unload its Treasure, at the very Door of the Heart.

But the Chyle is at yet in too crude a State, to be fit for the Animal Functions. Therefore it is thrown into the Lungs. In the spongy Cells of this amazing Laboratory, it mixes with the External Air, and its whole Substance is made more smooth and uniform. Thus improved it enters the Left Ventricle of the Heart, a strong, active, indefatigable Muscle. The large Muscles of the Arm or of the Thigh are soon wearied: A Day's Labour, or a Day's Journey exhausts their Strength. But the Heart toils whole Weeks, whole Months, nay Years, unwearied; is equally a Stranger to Intermision and Fatigue. Impelled by this, Part of the Blood shoots upward to the Head; Part rolls thro' the whole Body.

But how shall a Stream divided into Myriads of Channels, be brought back to its Source? Should any Portion of it be unable to return, Putrefaction, if not Death, must ensue. Therefore the All-wise Creator has connected the Extremities of the Arteries, with the Beginning of the Veins: So that the same Force which darts the Blood thro' the former, helps to drive it thro' the latter. Thus it is re-conducted to the great Cistern, and there played off afresh.

Where two opposite Currents would be in Danger of clashing, where the Streams from the Vena Cava and Vena ascendens co-incide, a fibrous Excrecence interposes, which like a projecting Pier, breaks the Stroke of each, and throws both into their proper Receptacle. Where the Motion is to be speedy, the Channels either forbear to wind (as in the Great Artery which descends to the Feet) or to lessen in their Dimensions, as in every Interval between all the Ramifications. When the Progress is to be retarded, the Tubes are variously convolved or their Diameter contracted. Thus guarded, the living Flood never discontinues its Course, but Night and Day, whether we sleep or wake, still perseveres to run briskly thro' the Arteries, and returns softly thro' the Veins.

But farther. The great Creator has made us an invaluable Present of the Senses, to be the Inlets of innumerable Pleasures, and the Means of the most valuable Advantages.

The Eye, in its elevated Stations, commands the most enlarged Prospects. Consisting only of Fluids, inclosed within Coats, it shews us all the Graces and Glories of Nature. How wonderful, that an Image of the hugest Mountains, and the widest Landscapes should enter the small Pupil! that the Rays of Light should paint on the Optic Nerve, paint in an instant of Time, paint in their truest Colours and exactest Lineaments, every Species of external Objects!

The Eye is so tender, that the slightest Touch might injure its delicate Frame. It is guarded therefore with peculiar Care, intrenched deep, and barricaded round with Bones. As the smallest Fly might incommode its

polished

polished Surface, it is farther protected by two substantial *Curtains*. In sleep when there is no Occasion for the sense, but a Necessity to guard the Organ, these *Curtains* close of their own accord. At any Time they fly together as quick as Thought. They are lined with an extremely fine Sponge, moist with its own Dew. Its crisply Palisades keep out the least Mote, and moderate the too strong Impressions of the Light.

As in our waking Hours we have almost incessant need for these little Orbs, they run upon the finest *Cassors*, rolling every Way with the utmost Ease: Which circumstance, added to the Flexibility of the Neck, renders our two Eyes as useful as a thousand.

The *Ear* consists of an outward Porch and inner rooms. The Porch, somewhat prominent from the head, is of a cartilaginous Substance, covered with eight Membranes and wrought into sinuous Cavities. These, like circling Hills, collect the wandering Undulations of the Air, and transmit them with a vigorous impulse, to the finely stretched Membrane of the *Drum*. This is expanded upon a Circle of Bones, over a polished, reverberating Cavity. It is furnished with *Braces* that strain or relax, as the Sound is faint or strong. The *Hammer* and the *Anvil*, the winding *Labyrinth*, and the sounding *Galleries*, these and other Pieces of Mechanism, instrumental to Hearing, are inexpressibly curious.

Amazingly exact must be the Tension of the *Auditory Nerves*, since they answer the smallest Tremors of the Atmosphere, and distinguish their most subtle Variations. These living Chords, turned by an Almighty hand, and spread thro' the echoing flesh, receive all the Impressions of Sound, and propagate them to the brain. These give Existence to the Charms of Music, and the still nobler Charms of Discourse.

The Eye is useless amidst the Gloom of Night. But the Ear hears thro' the darkest Medium. The Eye is Duty only in our waking Hours: But the Ear is always accessible.

As there are Concussions of the Air, which are discernible only by the Instruments of Hearing, so there are

are *odoriferous* Particles wafted in the Air, which are perceivable only by the *Smell*. The *Nostrils* are wide at the Bottom, that more Effluvia may enter, narrow at the Top, that when entered they may act more strongly. The Steams that exhale from fragrant Bodies, are fine beyond Imagination. Microscopes that shew thousands of Animals in a Drop of Water, cannot bring one of these to our Sight. Yet so judiciously are the olfactory Nets set, that they catch the vanishing Fugitives. They imbibe all the roaming Perfumes of Spring, and make us banquet even on the invisible Dainties of Nature.

Another Capacity for Pleasure our bountiful Creator has bestowed, by granting us the Powers of *Taste*. This is circumstanced in a Manner so benign and wise, as to be a standing Plea for Temperance, which sets the finest Edge on the Taste, and adds the most poignant Relish to its Enjoyments.

And these Senses are not only so many Sources of Delight, but a joint Security to our Health. They are the Inspectors that examine our Food, and enquire into the Properties of it. For the Discharge of this Office they are excellently qualified, and most commodiously situate. So that nothing can gain Admission, till it has pass'd their Scrutiny.

To all these, as a most necessary Supplement, is added the Sense of *Feeling*. And how happily is it tempered between the two Extremes, neither too acute, nor too obtuse! Indeed all the Senses are exactly adapted to the Exigencies of our present State. Were they strained much higher, they would be Avenues of Anguish: Were they much relax'd, they would be well nigh useless.

The crowning Gift which augments the Benefits accruing from all the Senses, is *Speech*. Speech makes me a Gainer by the Eyes and Ears of others, by their Ideas and Observations. And what an admirable Instrument for articulating the Voice, and modifying it into Speech, is the *Tongue*? This little Collection of muscular Fibres, under the Direction of the Creator, is the Artificer of our Words. By this we communicate the

Secret

Secrets of our Breasts, and make our very Thoughts audible. This likewise is the efficient Cause of Music; it is soft as the Lute, or shrill as the Trumpet. As the Tongue requires an easy Play, it is lodged in an ample Cavity. It moves under a concave Roof, which gives additional Vigour to the Voice, as the Shell of a Violin to the Sound of the Strings.

Wonderfully wise is the Regulation of *voluntary* and *involuntary* Motions. The Will in some Cases has no Power: In others she is an absolute Sovereign. If she command, the Arm is stretched, the Hand is closed. How easily, how punctually are her Orders obeyed! To turn the Screw, or work the Lever, is laborious and wearisome! But we work the Vertebrae of the Neck, with all their appendant Chambers; we advance the Leg, with the whole incumbent Body: We rise, we spring from the Ground, and tho' so great a Weight is raised, we meet with no Difficulty or Fatigue.

That all this should be effected without any Toil, by a bare Act of the Will is very surprizing. But that it should be done, even while we are entirely ignorant of the Manner in which it is performed, is most astonishing! Who can play a single Tune upon the Spinnet, without learning the Difference of the Keys? Yet the Mind touches every Spring of the human Machine, with the most masterly Skill, tho' she knows nothing at all of the Nature of her Instrument, or the Process of her Operations.

The Eye of a Rustic, who has no Notion of Optics, or any of its Laws, shall lengthen and shorten its Axis, dilate and contract its Pupil, without the least Hesitation, and with the utmost Propriety: Exactly adapting itself to the particular Distance of Objects, and the different Degrees of Light. By this Means it performs some of the most curious Experiments in the Newtonian Philosophy, without the least Knowledge of the Science, or Consciousness of its own Dexterity!

Which shall we admire most, the Multitude of Organs? Their finished Form and faultless Order? Or the Power which the Soul exercises over them? Ten thousand

land Reins are put into her Hands: And she manages all, conducts all, without the least Perplexity or Irregularity. Rather with a Promptitude, a Consistency and Speed, that nothing else can equal!

So fearfully and wonderfully are we made! Made of such complicated Parts, each so nicely fashioned, and all so exactly arranged; every one executing such curious Functions, and many of them operating in so mysterious a Manner! And since Health depends on such a numerous Assemblage of moving Organs; since a single Secretion stopped may spoil the Temperature of the Fluid, a single Wheel clogged may put an End to the Solids: With what holy Fear, should we pass the Time of our sojourning here below! Trusting for continual Preservation, not merely on our own Care, but on the Almighty Hand, which formed the admirable Machine, directs its Agency and supports its Being!

CHAP. II.

Of the Natural State of the Human Body.

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| 1. <i>What the Natural State of the Body means?</i> | 8. <i>The Hearing;</i> |
| 2. <i>Of the Circulation of the Blood;</i> | 9. <i>The Smelling;</i> |
| 3. <i>Of Respiration;</i> | 10. <i>The Tasting;</i> |
| 4. <i>Of Chylification;</i> | 11. <i>The Feeling;</i> |
| 5. <i>Of Nutrition;</i> | 12. <i>Of Hunger and Thirst;</i> |
| 6. <i>Of the Senses;</i> | 13. <i>Of Sleep;</i> |
| 7. <i>Of the Sight;</i> | 14. <i>Of Local Motion;</i> |
| | 15. <i>Of the voluntary and involuntary Motions.</i> |

1. **T**HAT is the Natural State of the Human Body, wherein all Parts of it duly perform their Natural Operations. The Chief of these are, the Circulation of the Blood, Respiration, Chylification, Nutrition and Motion.

2. That

2. That the Blood circulates thro' the whole Body appears hence. Any of the Arteries being tied with a Thread, will swell and beat between the Bandage and the Heart, but grow flaccid between the Bandage and the Extremities of the Body. And if the Artery be cut between the Bandage and the Heart, Blood streams out, even to Death: But if it be cut between the Bandage and Extremities, very little Blood comes out. The vital Blood therefore flows from the Heart thro' the Arteries, toward the Extremes of the Body, and still out of a wider Part into a narrower, out of the Trunk into the Branches.

Any of the larger Veins being tied with a Thread, swells between the Extremes and the Bandage, but grows flaccid between the Bandage and the Heart. If opened in the former Part, it bleeds largely; if in the latter, scarce at all. The Blood therefore flows from all the Extremes, thro' the Veins into the Heart, and still from the narrower Parts of the Vein to the larger, from the Branches to the Trunk.

Upon the whole it is evident, that all the Arteries are continually bringing the Blood from the Left Ventricle of the Heart, thro' the Trunks of the Arteries into their Branches, and from thence to all Parts of the Body: And on the contrary that all the Veins, (except the Vena Portæ) are continually bringing it back from all Parts of the Body, thro' the small Branches into the larger, and thence thro' the Trunks and Vena Cava into the Right Ventricle of the Heart.

Anatomists

* Late Writers have pursued the Globules of Blood to a great Length, and found several Orders of them. The large ones visible to the naked Eye, are Globules of the *first Order*. Each of these is composed of six smaller, joined together in a very regular Way. But sometimes a red Globule is seen loosning, and breaking into these compounding Spherules. And sometimes one may perceive these running together, and beginning the Composition of a new red Globule. These smaller Spherules they call Globules of the *second Order*. But we are not to stop here. There are in the Blood a great many Particles six Times less than these. Globules of the *third Order* are compounded of these smaller ones, which therefore are Globules of the *third Order*.

Anatomists and Physicians have generally determined the Quantity of Blood in the human Body, to be between fifteen and twenty-five Pounds. But Dr. Keil shews from many Instances of profuse Hemorrhages, that a far greater Quantity must be allowed. Otherwise the Patient could never have furnished, or at least, not survived such Evacuations; the least of which exceeded the whole Quantity of Blood, supposed to be in the Body.

In Reality, the Quantity of Blood in an human Body, is difficult to be determined. Bleeding to Death, the usual Method, can never shew what is its true Quantity: Because no Animal can bleed longer, than while the Great Artery is full; which will be a longer or a shorter Time, as the wounded Artery is smaller or greater. And the Great Artery must always be, the first Vessel that empties.

The only certain Way of calculating is, to find what Proportion the Cavities of the Vessels of which the whole Body is composed, bear to the Thickness of the Coats. This in the Veins and Arteries may be exactly found. But in the other Vessels we only know the Quantity of Fluid they contain, by carefully evaporating as much as possible. Thus the Doctor found the Fluids to be in the

Farther. There are innumerable Blood Vessels of such Smallness, that none of the above-mentioned Globules can pass them: So that we cannot but suppose still smaller Globules. The Diameter of some Vessels, is less than the Eighth Part of the Diameter of a red Globule: So that the Particles passing thro' them, must be above five hundred Times less than those Globules. Nay, on a careful Examination, we perceive Vessels narrower, than the tenth Part of the Diameter of a red Globule; which consequently can transmit Spherules no greater, than the thousandth Part of a red Globule.

On the whole then, each Globule of the first Order is made up of six of the Second: These of six of the Third; those of six of the Fourth; these of six of the Fifth, and so on. And accordingly we find, the Globules of the highest Orders, may be broken down into their compounding Particles.

The Diameter of a common Red Globule is about the one 1938th Part of an Inch. The Diameter of a Globule of the tenth Order is less than the one 400000th Part of an Inch.

the Arteries as 17 to 1; in the Veins as 15,6 to 1: in the Bones as 1 to 1. The least of these Proportions shews the Liquors to be one half of the Weight of the Body. And if a Calculation be made, on the Proportion of the Blood in the Arteries also to their Coats in a Body weighing 160 Pounds, there will be found 100 Pounds of Blood or circulating Fluid.

In a Fœtus the Circulation is performed in a peculiar Manner. The Septum which separates the two Ventricles of the Heart is pierced thro' with an Aperture, called the *Foramen Ovale*, and the Pulmonary Artery, a little after it has left the Heart, sends out a Tube into the descending Aorta, called the *Communicating Canal*. When the Fœtus is born, the *Foramen ovale* closes, and that Canal dries up into a simple Ligament.

The Fœtus while in the Womb receives little Air. Its Lungs therefore cannot swell and subside. They continue almost at rest: Nor can they allow the Blood to circulate, either in Abundance, or with Ease. Nature therefore has excused them from the Passage of the greatest Part of the Blood, and has contrived the *Foramen ovale*, by which Part of the Blood of the Vena Cava passes thro' the Right Ventricle into the Left. And by this Means it is found as far on its Journey, as if it had passed the Lungs. But this is not all. For that Blood of the Cava, which missing the *Foramen ovale*, passes from the Right Auricle into the Right Ventricle, being still too much to pass by the Lungs, the Communicant Canal intercepts Part of it, and pours it immediately into the descending Aorta.

3. Respiration is performed by receiving the Air into the Lungs, and breathing it out alternately. In the former, the Cavity of the Breast is enlarged, by the sinking of the Diaphragm, and the Erection of the Ribs, thro' the Force of the Muscles placed between them. In the latter, it is contracted, the Diaphragm rising and the Ribs falling again. Whenever the Cavity of the Breast is enlarged, the Air by its Weight naturally presses into it, and mixing with the Blood in the Vesicles of the Lungs, makes it more fluid, globular and fit for Motion.

Air is likewise absolutely necessary in the Body, to counter-act the Pressure of the Outward Air.

The Blood in the Lungs of a Foetus has not the Advantage of Respiration. But it receives a Portion of Air, transmitted with its Mother's Blood by the Umbilical Vessels, to be diffused thro' the Body. This is quite necessary, as appears hence: Tie the Navel String very tight, and the Child dies, like a Man strangled.

The principal Use of Respiration is, to push the Blood from the Right to the Left Ventricle of the Heart. Hence it is, that Persons strangled so suddenly die, because with Respiration, the Circulation of the Blood ceases. And this is the true Cause of the Diastole of the Heart: The Weight of the incumbent Atmosphere, being the true Antagonist to all the Muscles that serve both for Inspiration and the Contraction of the Heart. As in the Elevation of the Ribs, a Passage is opened for the Blood into the Lungs, so in the Depression thereof, by the subsiding of the Lungs and the Compression of the Blood-vessels thereby, the Blood is driven thro' the Pulmonary Vein, into the Left Ventricle of the Heart. And this, together with the General Compression of the Body, by the Weight of the Atmosphere, is that Power which causes the Blood to mount in the Veins, when the Force impress on it by the Heart is nearly spent, and which forces the Heart itself from its natural State of Contraction, to that of Dilatation.

When in an ordinary Expiration, the Pressure on the Larynx is two Ounces, the Pressure on the whole internal Substance of the Lungs, is 13412 Pounds. So vast is the Extent of the Surface of the Vesicles, on which it was necessary the Blood should be spread in the finest capillary Vessels, that each Globule of Blood might as it were immediately receive the whole Force of the Air, and thereby be broken into smaller Parts, fit for Secretion and Circulation.

And hence we see the Reason for the Structure of the Lungs. For since all the Blood is to pass thro' them, in order to receive the Effect of the Air, and that this could not be done, unless it were diffused in very small Vessels:

It was necessary the Surface on which they were to be spread, should be proportioned to their Number. And this is admirably well provided for, by the Fabric of the Lungs.

If the Diameter of the Trachea at the Time of every Expiration were the same in all, and the Weight of the Air always equal, the Pressure on the Lungs would be always the same. But as the Difference between its least and greatest Gravity, is no less than a Tenth Part of the whole, that Pressure is likewise greater by a Tenth Part at sometimes than it is at others.

This is a Difference which the Asthmatic must sensibly feel; especially as they breathe thicker, that is, every Expiration is performed in less Time. In Truth, these feel a Difference in the Air, upon the greatest Rise and Fall of the Barometer, equal to above One third of its Pressure in ordinary Breathing.

The alternate Dilatation and Contraction of the Thorax are so necessary to Animal Life, that there is no Animal without this, or something analogous to it. Fishes and Insects have no dilatable Thorax. But Fishes have Gills, which receive and expel the Water alternately, whereby the Blood-vessels suffer the same Alterations of Dimension, as those in our Lungs do. And Insects have Air-vessels distributed thro' the whole Trunk of their Bodies. By these they communicate with the external Air thro' several Vent-holes, to which are fastened so many Windpipes, which send Branches to all Parts, and seem to accompany the Blood-vessels all over the Body, as they do in our Lungs only. And hereby in every Inspiration the whole Body is dilated, and in every Expiration compressed.

4. *Chylification* is preceded by *Digestion*, which is much illustrated by Mr. *Papin's Digester*. This is a Vessel wherein Meat is put, with just as much Water as will fill it. Then the Lid is screwed on so close, as to admit of no External Air. The Meat herein is by the Flame of a small Lamp, in Six or Eight Minutes brought to a perfect Pulp. In a few Minutes more the hardest Bones are reduced to a Jelly. No Air entering, the Successions caused by the Air inclosed in the Flesh, resolve the

into one homogeneous Body. It is just so in Digestion. In Proportion to its Heat, the Stomach does the very same Thing as the Digester.

Add to this, that the Muscular Coat of the Stomach continually contracting, and pressing its Contents by its peristaltic Motion, occasions a more intimate Mixture, and works the more fluid Parts, thro' the Pylorus into the Duodenum. Along the Sides of this and the other small Intestines the Lacteals are planted: Into the Minute Orifices whereof, the Chyle, or finer Part of the Mass is received. The lacteal Veins of the first Kind, discharge themselves into the Glands of the Basis of the Mesentery. The Chyle is afterward received by the Lacteals of the second Kind, and conveyed into Glands between the two Tendons of the Diaphragm. And hence it is carried to the Heart, where it mixes with the Blood.

5. By the perpetual Motion of the Fluids, (especially in the Minute Vessels) as well as the constant Action of the Muscles, small Particles are continually worn off, from the Solids of the Body. The Fluids likewise are continually diminishing. And hence every animal Body, by the very Condition of its Frame, is liable to Destruction. To prevent this, a Restitution must be made to the Juices and Solids of the Body, equal and similar to what is lost. And this we call *Nutrition*.

It seems to be performed thus. The Blood forcibly thrown by the Heart into the Arteries, endeavours to go out every Way thro' the Pores. But these are usually too small, to give its Particles a free Passage. They can only pass, where any of the Pores are open. Here one will naturally follow another in a Line, and constitute a Fibre or Part of a Fibre. When as much is thus added to one End of the Fibre, as is wasted at the other, the Body is *nourished*: When more is added than is wasted, we are said to *grow*.

We see then how absolutely necessary Food is, to repair the constant Decay of the Body: So that few Men or Women can live without it, above five or six Days. And yet the abstaining from it for a Season has its Use. Indeed great is the Efficacy of Abstinence, both in prolonging

longing Life, beyond its usual Period, and in the Cure of many stubborn Disorders.

6. As without Respiration and Nutrition we cannot live at all, so without *Sense*, Life would be like Death. In every Sensation there is 1. An outward Object; 2. Its Action on the Organ of Sense, 3. A Perception of it in the Mind. The Action of the Object on the Organ, is by Means of the Nerves communicated to the Brain. And then, not otherwise, the Perception follows. But how none but he that made Man can explain.

7. In Sight the Action on the Organ is performed just in the Manner of that in a Camera Obscura. The

G 3

Rays

Detto *Cornaro*, a Nobleman of *Venice*, after all other Means had failed, so that his Life was despaired of at Forty, recovered and lived to near an Hundred, by mere Dint of Abstinence.

'Tis surprizing to observe, to what an Age those antient Christians lived, who retired from the Fury of Persecution, into the Deserts of *Arabia* and *Egypt*. They drank only Water, and took no other Food than 12 Ounces of Bread in 24 Hours. On this *St. Anthony* lived 105 Years, *Epiphanius* 115, *Simon Stylites* 112 and *Remwald*, an hundred and twenty.

Among Animals we see surprizing Instances of long Abstinence. Several Species pass 4, 5, or 6 Months every Year without eating or drinking. So Tortoises and Dormice regularly retire at the Season to their respective Cells. Some Kinds get into Ruins, or the Hollows of Rocks; others, into Clefts of Trees. Some sleep in Holes under the Earth: others bury themselves under Water.

The Serpent-kind bear Abstinence to a Miracle. Rattle-snakes will subsist many Months without Food. Dr. *Spaw* saw two *Egyptian* Serpents, which had been kept in a Bottle five Years, (on a small Quantity of Sand wherein they coiled themselves up) without any Sort of Food. Yet when he saw them they had just cast their Skins, and were as lively as if just taken.

There have been Instances even of Men passing several Months, with scarce any Sustainance. So *Samuel Chilton* of *Tisbury*, near *Bath*, in the Year, 1693, 1694 and 1695, slept sometimes four Months, and sometimes above six together, with very little Food: And six Weeks without any, but a little Tent conveyed with a Quill thro' his Teeth.

It is not improbable, that the Air itself furnishes some nutritive Particles. It is certain, there are Substances of all Kinds, floating in the Atmosphere. And that an Animal Body may be nourished hereby, is evident in the Case of Vipers. These if taken when first brought forth, and kept from every Thing but Air, will yet grow very considerably in a few Days.

Rays of Light, reaching from the Surface of Bodies to the Eye, variously penetrate the Coats and Humours of it, and paint on the Bottom of the Eye the Images of the Things which we see. This is communicated by the Optic Nerve to the Brain, and then the Perception, which is properly Sight, follows. But the Eye has many Advantages above a Camera Obscura: Not only as it can be moved various Ways, by the Help of its Muscles; but also as the Pupil, by the Help of the Iris, is instantly either dilated or constricted, according to the Degree of Light. The Eye likewise accommodates itself to the various Distances of the Objects, the Bottom of the Eye approaching to or receding from the ChrySTALLINE Humours, as the Object is nearer or farther off.

8. *Sound* is a tremulous Motion of the Air, produced by the Stroke or Collision of Bodies. *Hearing* is performed in the following Manner. The undulating Air enters the outward Cavity of the Ear, and then strikes upon the Drum; from which the Motion is communicated to the little Bones within, and the Air contained in the inner Cavity. This by Means of the Nerve conveys it to the Brain, and then follows the Perception which we term *Hearing*.

9. The fine Effluvia which spread every Way from odorous Bodies, ascending with the Air into the Nostrils, variously twitch the Filaments of the olfactory Nerves, according to the Variety of their Natures. When this Motion is by those Nerves communicated to the Brain, the Perception follows which is called *Smelling*.

10. It was observed before, that the Surface of the Tongue is filled with small Papillæ, which are no other than fine Ramifications of the Gustatory Nerve. These are variously moved, by the Particles of Meat and Drink. And this Motion being by that Nerve transmitted to the Brain, that Perception arises which we stile *Tasting*.

11. The Organ of *Feeling* is the Skin in general, with which innumerable nervous Papillæ are interwoven, which being moved by the slightest Touch of other Bodies, convey that Motion to the Brain. But these Papillæ abound in all the Extremities, particularly the Palms of the Hand, and the Tips of the Fingers. And hence it is, that

that the Sense of Feeling is far more exquisite in those than in other Parts.

12. Nearly allied to the Senses are the Natural Appetites, particularly *Hunger* and *Thirst*. The usual Way of accounting for them is this. When the Food now reduced to a Pulp, is express'd out of the Stomach, it is of Course contracted by its muscular Coat. This causes the inner Coat to lie in Folds; which by Means of the peristaltic Motion, rubbing lightly on each other, occasion the uneasy Sensation which we term *Hunger*. This is felt first in the upper Orifice, which is first evacuated. But as by Degrees the rest of the Contents are expelled, this rubbing of the Membranes on each other spreads over the whole Stomach, and renders our Hunger more urgent.

This uneasy Sensation is increased by the Acidity, which the Blood in the Arteries of the Stomach contracts thro' long Abstinence, its soft, balsamic Parts having been all drawn off. Likewise its Velocity is considerably augmented, when we have not eaten for some Time.

Hence it is, that *Hunger*, if it continues long, will occasion a violent Fever: that young Persons, and those who labour hard, or are of a bilious Constitution, are soonest hungry: Whereas those whose Humours are thick and viscid, are not so soon incommoded therewith.

Hot Vapours ascending from the Stomach, and drying the Throat and Mouth, are supposed to be the Occasion of that uneasy Sensation, which we term *Thirst*.

I say, *are supposed*. For I apprehend nothing can be known with any Certainty upon the Head. In like Manner it is supposed, that we are then *awake*, when the Nerves are braced, and filled with Animal Spirits; and that when they are unbraced and empty, we *sleep*. But who can give any satisfactory Account of Sleep? Some ascribe it to the Stoppage of the Nerves: Some to the Quiescency, and others to a Deficiency of the Animal Spirits. The Truth is, we are ignorant of the whole Affair; and no more understand Sleep than we do Death.

But this we know, that during Sleep several Functions are suspended, the Organs of Sense are at rest, the
Muscles

Muscles are quiescent, so that hardly any Spirits flow thro' them. The Fibres of the Nerves are little changed, and an Equilibrium obtains throughout. There is no Difference of Pressure on the Vessels, nor of Velocity in the Humours, which circulate equally thro' all the Canals. Meantime, all disturbing Causes being at rest, the wasted Humours are restored, and the Particles supplied, which were worn off the Solids.

We may observe farther, that when the Head is hot, and the Feet cold, we cannot sleep; that Perspiration is twice as great while we sleep as while we are awake; that too much Sleep makes the Senses dull, the Memory weak, and the whole Body listless; that Sleep will for a considerable Time supply the Place of Meat and Drink: That a Foetus sleeps always; Children much; Youths more than Adults, and they than old Men.

Let

To speak a little more particularly. While we are awake there is a continual Motion of the voluntary Muscles, of the Parts subservient to Sense, and to the Affections, all which stimulate the Nerves, Blood-vessels and Heart. Thus the finer Parts of the Blood, are continually wasted, whence Weariness ensues: and if the Vigilance be continued, a feverish Heat and sensible Loss of Strength.

As the Night advances, a Weight falls on the large Muscles and their Tendons, and the Mind becomes heavy. The Powers that hold the Body erect, begin to shrink from their Office, the Eye-lids close, the lower Jaw falls down, the Head nods, and we take less Notice of outward Objects, till at length all the Thoughts are in Confusion, and a Sort of Delirium ensues, from whence there is a Transition to sleep, not known to us. This is hastened by Darkness, Composure of Mind and Absence of Irritation from all Parts of the Body.

Again, Whatever weakens the natural Powers, inclines to and increases Sleep: Such as Loss of Blood, cooling Medicines, yea the Cold of the external Air. Add to these, whatever calls off the Quantity of Blood flowing to the Heart, as warm Bathing of the Feet, a plentiful Ingestion of Food into the Stomach: Likewise whatever lessens the Motions of the Spirits, whether in the Brain, or Stomach, Heart or Arteries. On the Contrary, some hot Medicines induce Sleep, by causing a greater Afflux of Blood to the Brain. The same Effect have some Fevers; as also Fauness, and whatever else retards the venal Blood. In all these Cases, the Blood collected in the Head compresses the Brain, so as to lessen the Course of the Spirits into the Nerves.

Let us consider in another View these remarkable Incidents of our Frame, *Sleep* and *Dreams*: So remarkable, that they are a Kind of Experimental Mystery, a standing Miracle. Behold the most vigorous Constitution, when resigned to the Slumbers of the Night. Its Activity is oppressed with Indolence; its Strength suffers a temporary Annihilation. The Nerves are like a Bow unstrung, the whole Animal like a motionless Log. Behold a Person of the most delicate Sensations and amiable Dispositions. His Eyes, if wide open, discern no Light, distinguish no Objects. His Ears with the Organs unimpaired, perceive not the Sounds that are round about them. The exquisitely fine Sense of Feeling is overwhelmed with an utter Stupefaction. Where are his social Affections? He knows not the Father that begat him, the Friend that is as his own Soul. Behold the most ingenious Scholar, whose Judgment traces the most intricate Sciences, whose Taste relishes all the Beauties of Composition. The thinking Faculties are unhinged, and instead of close-connected Reasonings, there is nothing but a disjointed Huddle of absurd Ideas. Instead of well-digested Principles, nothing but a disorderly Jumble of crude Conceptions.

Yet

Sleepiness is likewise produced by any Compression of the Brain; whether from extravasated Blood, a depressed Part of some Bones, or a Collection of serous Water within the Ventricles.

Sleep therefore sometimes rises from a Defect of the Spirits; But also from a collapsing of the nervous Fibres, thro' which the Spirits pass from their Fountain to all Parts of the Body.

It is hindered by intense Thought, Pain of Body, and strong Emotions of Mind: All which urge the Spirits on, and prevent the nervous Fibres from collapsing.

In Sleep the Heart is gradually restored from its quick and almost feverish Pulsation, to its slow and calm Motion: The Breathing is slower and smaller, the Motion of the Stomach and Intestines, the Digestion of the Aliments and the Progression of the Faeces are diminished. At the same Time the thinner Juices move more slowly, while the more Gross are called together, the Fat is accumulated in its Cells, and the nutritive Particles adhere more plentifully to the inner Surfaces of the small Vessels, and the Sides of the Fibres. Thus while the Spirits are secreted with a less Consumption, they are by Degrees accumulated in the Brain, so as to distend and fill the collapsed Nerves. And then we awake out of Sleep.

Yet no sooner does he awake, than he is possess'd of all his former Endowments. His Sinews are braced and fit for Action, his Senses alert and keen. The frozen Affections melt with Tenderness: the romantic Visionary is again the Master of Reason. And (what is beyond Measure surprizing) the intoxicated Mind does not work itself sober by slow Degrees, but in the twinkling of an Eye, is possess'd of all its Faculties! Why does not the Numbness, which seiz'd the Animal Powers, chain the Limbs perpetually? Why does not the Stupor, that deadens all the Sense, hold fast its Possession? When the Thoughts are once disadjusted, why are they not always in Confusion? How is it, that they are rallied in a Moment and reduced from the wildest Irregularity to the most orderly Array? From an Inactivity resembling Death, and from Extravagancies little differing from Madness, how suddenly is the Body restored to Vigour and Agility? How instantaneously is the Mind re-established in Sedateness and Harmony! Surely *this is the Lord's Doing. And it is marvellous in our Eyes!*

14. That all Motion is performed by Means of the Muscles, all Men are now agreed. And it is supposed that the Motions of the Muscles proceed, from the influx of the Animal Spirits; which, entering them by Means of the Nerves, swell and shorten the Belly of the Muscle, and thereby draw the Extremities together, and move the Parts connected therewith. But all this likewise is mere Conjecture. God only knows his own Work.

15. That some Motions are *Voluntary*, and some are not, is another amazing Proof of the Creator's Wisdom. Those which are absolutely necessary for the Conservation of the Machine, as the Beating of the Pulse, and the Circulation of the Blood, go on by a Kind of mechanic Law, which no Way depends upon our Will: While a thousand other Motions begin and end, by a single Act of our Will, when we please. But how this Bodily Motion is connected with that Act of our Mind, who is able to explain?

CHAP.

C H A P. III.

Of the preternatural State of the Human Body.

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| 1. <i>What the preternatural State of the Body means.</i> | 5. <i>Those of the Animal Spirits:</i> |
| 2. <i>The Variety of Diseases,</i> | 6. <i>The remote Causes of Diseases;</i> |
| 3. <i>Reduced to three Classes, those of the Solids;</i> | 7. <i>Of Fevers:</i> |
| 4. <i>Those of the Fluids, particularly, the Blood:</i> | 8. <i>The Way to preserve Health:</i> |
| | 9. <i>Of Life and Death.</i> |

1. **W**HEN the Structure or Disposition of the Parts of the Body is so disturbed and disordered, that the natural Operations are no longer performed; or not in the Manner they ought: This is a *preternatural State* of the Body, otherwise termed a *Disease*.

2. There cannot but be great Variety of Diseases, whether we consider the Manner, wherein that Structure or Disposition is disturbed, the Part wherein each Disease has its Seat, or the various Effects and Circumstances of them. Some Diseases only *hurt* the Use of the Parts; some wholly *destroy* it. Some effect this or that Part; others the whole Body. Some disorder the Body, some the Mind; and others both Mind and Body.

3. But they are all reducible to three Classes, those of the *Solids*, of the *Fluids* and of *Both*. The solid Parts may be bruised, wounded, swelled, or removed out of their natural Place.

4. The

* It is a wonderful Provision which Nature makes in one of the most dreadful Calamities incident to the Solids. When a Bone is broken, let it only be replaced, and preserved in that Situation, and Nature does the rest, by supplying the divided Parts with a *Callus*.

4. The Diseases of the *Fluids* lie chiefly in the Blood, when it is either too thick and fizy, whereby its Motion becomes too languid and slow, whence spring the Diseases owing to Obstruction: Or too thin. From the former Cause arise Leprosies, Schirrhuses, Lethargies, Melancholy, Hysteric Affections, and if at the same Time it abound in acid Salts, the sharp Points of these tear the tender Fibres, and occasion the Scurvy, Kings-Evil, Consumption, with a whole Train of painful Distempers. Fevers frequently arise from the too great Thinness of the Blood.

5. As to the Diseases ascribed to the *Animal-Spirits*, some are thought to proceed from the Suppression or Diminution of their Motion, as Apoplexies and Palpitations: Some from their excessive or irregular Motion, as Madness, Convulsions, Epilepsies.

6. Such

This oozes out from the small Arteries and bony Fibres of the divided Parts, in Form of a Jelly, and soon fills up the Cavities between them. It soon grows cartilaginous, afterwards bony, and joins the fractured Parts so firmly, that the Bone will be more easily broken in any other Part than in that.

A Callus of a different Kind is formed on our Hands and Feet. This is composed of several Layers of Particles loosely connected. These if steeped in fair Water easily separate; and then are found, if viewed thro' a Microscope, to be all of one Shape, resembling that of a Weaver's Shuttle, broad in the Middle, and pointed at each End. Being steeped again, they divide into a great Number of smaller Particles, all of the same Figure with the first.

The Thickness of the Skin in the Hands of those who Labour hard, is wholly owing to vast Numbers of these Particles, which combine together, but so loosely, that they are easily separated on moistning. That thick Skin is composed of several Layers of different Thickness, which have been added from Time to Time: Each of which Layers is only a Congeries of almost an Infinity of these Particles.

But People who Labour ever so hard, will have little Callus on their Hands if they wash them often. The Washing the Hands daily rubs off a great Quantity of these Scales. Indeed it is surprising to see, how large a Quantity of them is daily thrown off from our Hands and Feet, tho' from no other Part of the Body. We may learn from this the great Bounty of Nature, in so carefully supplying the Parts designed for Walking or Labour, with an additional Matter for their Defence, which is not in any other Part of the Body.

6. Such are the Proximate Causes of Diseases. As to the Remote, the chief are these, 1. Intemperance in Meat or Drink, either with regard to the Quantity or Quality: 2. Want of Exercise, or Excess therein: 3. Immoderate Sleep or Watching: 4. Unwholesome Air: 5. The Diminution of some Natural Evacuation: 6. Irregular Passions. All or any of these affect the Temperature and Motion of the Blood and Spirits.

7. But it can scarce be conceived, after all that has been said and wrote on almost every Subject, how very little is known to this Day, concerning the Causes of Diseases. In most Cases the most skilful Physicians acknowledge they have nothing but Conjectures to offer. We may give a Specimen with regard to *Fevers*, the most common of all Distempers. These are of various Kinds: At present we will speak of *intermitting Fevers* only. Most of these agree in the following Symptoms. During the Approach of the Fit, Cold and Shivering seize the Body, with a small and slow Pulse. Heat succeeds, with a quick, strong, hard Pulse, followed by Sweat and a softer Pulse. These Fits return at stated Times.

It is supposed, that these Changes in the Blood arise, from some foreign Matter mixt with it, which it cannot readily assimilate, and which therefore must in some Measure hinder its Motion: Perhaps because the Particles of it are too large, too long, or branching out. When the Circulation is hindred or retarded, *Chilnes*s naturally follows. And if these Particles sticking in the finer Passages, are prest on by the affluent Blood, this will occasion both a Shock and Tremor of the Muscles, and make the Pulse more weak and slow. But when they are at length broken and comminuted by the continued Afflux of the Blood, it will flow more violently, and of Course occasion Heat, which driving the Blood to the Surface of the Body, many of its thinner Particles will burst thro' the Pores, in the Form of Sweat. As to the Fevers returning at stated Times, it is supposed the peccant Matter, is generated from Time to Time, and mingled with the Blood afresh; whence the same Symptoms of Course return, and that with more or less

violence, as more or less of that Matter is generated. And as this is done more swiftly or slowly, the Fever returns in one, two or three Days. But all this is mere Conjecture. It may be so ; and it may not. So that tho' we may *guess* much, we *know* nothing about it.

8. It is sufficient for us to know, how we may avoid Diseases, whether we can account for them, or not. To this End we should avoid whatever in Meat, Drink, Motion or Rest, is likely to produce any considerable Change in the Blood. The Body likewise should be as far as possible accustomed, to bear some Change of Food, Air and other Externals, that if we should at any Time be constrained to make such a Change, no ill Consequence may insue. But no precise Rule can be laid down, which will suit all Constitutions. Every Man must consult his own Reason and Experience, and carefully follow them.

9. As long as the Soul and Body are united, a Man is said to be *alive*. But it is extremely difficult to determine, the precise Time at which Life ceases, or what that is, which is absolutely necessary to the Continuance of it. Is Respiration ? But when this is entirely ceased, as is the Case in a Person strangled, blow strongly into the Lungs, and they play again ; which shews he was not *dead* before. Is the Beating of the Heart ? But when this also is ceased, in the fore-mentioned Case, take the same Method, and when the Lungs begin to play, the Heart begins to beat anew. Is the Circulation of the Blood ? But Persons drowned, who have been so long under Water, as to have no Pulse remaining in any Artery, and consequently no Circulation, have recovered by the Use of proper Means, and lived many Years after. Is the Fluidity of the Blood ? Nay, but it is a common Thing in *Sweden*, to recover to Life one who has been twenty four Hours under Water ; and who not only has no Pulse, but is as stiff all over, as any dead Corpse can be. What then is *Death* ? Undoubtedly it is the Separation of the Soul and Body. But there are many Cases wherein none but God can tell the Moment wherein they separate.

But

But what is properly a *Natural Death*? From the very Birth every Vessel in the Human Body, grows stiffer and stiffer, by the Adhesion of more and more earthly Particles to its inner Surface. Not only Solid Food supplies it with these, but every Fluid that circulates thro' it. Hereby more and more of the small Vessels are so filled up, as to be no longer pervious. In Proportion, the Coats of the larger Vessels grow harder, and their Cavities narrower. Hence the Dryness and Stiffness of all the Parts, which are observable in Old Age. By this Means more and more of the Vessels are destroyed, the finer Fluids secreted in less Quantity, the Concoctions weakened, and the Reparation of the decayed and injured Parts prevented. So that only the coarser Juices continue to run slowly thro' the larger Vessels, till these also not only become narrow, but stiff, bony and unelastic, till even the great Artery having lost its Spring, can propel the Blood no longer. And then follows Death by Old Age, which is a purely *Natural Death*. But this is a very rare Case: It is seldom Life is so long protracted: The Lamp of Life being easily blown out, when it burns with so feeble a Flame. So that the Age of Man seldom exceeds threescore Years and ten, before Dust returns to Dust.

Indeed soon after the Creation, when the Earth was to be peopled by one Man and one Woman, the wise Providence of God prolonged the Life of Man to above 900 Years. After the Flood, when there were three Men to people the Earth, their Age was cut shorter. And none of these Patriarchs, except *Shem*, attained to five hundred Years. In the next Century none reached 240: In the third, none but *Terah* lived 200: Men being then so increased, that they built Cities, and divided into different Nations. As their number increased, the Length of their Lives diminished, till about the Time of *Moses*, it was reduced to 70 or 80 Years, where it stands at this Day. This is a good Medium, so that the Earth is neither over-stocked, nor kept too thin of Inhabitants. If Men were now to live to *Methuselah's* Age, of 969 Years, or only to *Abraham's*

of 175, the Earth would be over-peopled. If on the contrary, the Age of Man was limited (like that of divers other Animals) to 10, 20 or 30 years, it would not be peopled enough. But at the present Rate, the Balance is nearly even, and Life and Death keep on an equal Pace.

This is highly remarkable, that wherever any Account has been taken, there is a certain Rate and Proportion in the Propagation of Mankind. Such a Number marry, and so many are born, in Proportion to the Number of Persons in every Town or Nation. And as to Births, two Things are very observable; One, the Proportion of Males and Females, fourteen Males to thirteen Females, which is exactly agreeable to all the Bills of Mortality. And this Surplusage of Males allows one Man to one Woman, notwithstanding the Casualties to which Men are exposed above Women. The other is, that a few more are born, than appear to die in any Place. This is an admirable Provision for extraordinary Emergencies, to supply unhealthy Places, to make up the Ravages of Epidemic Distempers, and the Depredations of War; and to afford a sufficient Number for Colonies, in the yet unpeopled Parts of the Earth. On the other Hand, those extraordinary Expences, are not only a just Punishment of Sin, but also a wise Means, to keep the Balance of Mankind even. So one would be ready to conclude, by considering the *Asiatic*, and other more fertile Countries, where prodigious Multitudes are swept away by Wars and Plagues; and still they remain full of People.

As to the Length of Life, it has been an ancient Opinion, that Men lived longer in cold Countries than in hot. But the reverse is true. The Inhabitants of the *Caribbee* Islands, usually live an hundred and fifty Years, In the *Molucca* Islands, the ordinary Life of the Natives is an hundred and thirty Years. In *Sumatra*, *Java*, and the neighbouring Islands, the Life of the Inhabitants, commonly extends to an hundred and forty Years; in the Realm of *Cassuby*, to 150. The *Brazilians* frequently live 160 Years, and many in *Florida* and *Iucatan* still longer,

Nor is this at all improbable. For there being no such Inequality of Weather in those Climates as in ours, the Body is not shocked by sudden Changes, but kept in a more equal Temper. And sickly Persons with us, when fixt to their Beds, and kept in an equal Degree of Heat, are often found to hold out many Years, who would otherwise scarce have survived one.

Before concluding this Head, we may observe one more eminent Instance of the divine Wisdom, in the great Variety throughout the World, of Men's Faces, Voices and Hand-writing. Had Men's Faces been cast in the same Mould, their Organs of Speech given the same Sound; and had the same Structure of Muscles and Nerves given the Hand the same Direction in Writing: What Confusion, what numberless Inconveniences must we have been exposed to? No Security could have been to our Persons, no Certainty of our Possessions. Our Courts of Justice abundantly testify the Effects of mistaking Men's Faces, or Hand-writing. But this the wise Creator has taken Care to prevent from being a general Case. A Man's Face distinguishes him in the Light, as his Voice does in the Dark: And his Hand-writing can speak for him when absent, and secure his Contracts to future Generations.

Lastly, How admirably has God secured the Execution of his Original Sentence, upon every Child of Man, *Dust thou art, and unto Dust shalt thou return?* From the Moment we live, we prepare for Death, by the Adhesion of Dust, mixt with all our Allments, to our native Dust; so that whatever we eat or drink, to prolong Life, must sap the Foundation of it. Thus in Spite of all the Wisdom of Man, and all the Precautions which can be used, every Morsel we take poisons while it feeds, and brings us nearer to the Dust from whence we came.

C H A P. IV.

Of the Soul, and of the Origin of Man.

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| <p>1. <i>There is something in Man which perceives the various Motions of the Body:</i></p> <p>2. <i>This Perception is sometimes continued, and recalled:</i></p> <p>3. <i>We know some Things in a more sublime Manner:</i></p> <p>4. <i>There is something in us which has an Appetite to sensible Things:</i></p> <p>5. <i>And another Appetite, which is often contrary to this:</i></p> <p>6. <i>How Philosophers account for the Direction of our Bodily Motions:</i></p> <p>7. <i>For the External Senses,</i></p> | <p>8. <i>The Imagination and Memory,</i></p> <p>9. <i>The Understanding, Will and Affections:</i></p> <p>10. <i>This may be so, or may not:</i></p> <p>11. <i>Of the Immortality of the Soul:</i></p> <p>12. <i>Of the Union of the Soul and Body:</i></p> <p>13. <i>Reason cannot discover the Origin of Man:</i></p> <p>14. <i>The Scriptural Account of it:</i></p> <p>15. <i>Of the Production of the Soul:</i></p> <p>16. <i>Of the Generation of the Body.</i></p> |
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1. **E**VERY one finds, there is something in himself, which perceives the Motions raised in his Body by outward Objects. For when we see, hear, taste, smell or feel, while the Objects affect our bodily Organs, we find also various Perceptions in our Mind, according to the Variety of those Objects.

2. We observe likewise, that after the Objects are removed, those Perceptions often continue, yea and are variously mixt and compounded together, which we term *Imagination*. And a long Time after, when those Objects are not only removed, but even cease to exist, those Perceptions return into our Mind. And this we call *Memory*.

3. And

3. And as we *perceive* these outward Objects, so we *know* that we do perceive them. The Mind can look inward upon itself, and *reflect* upon its own Perceptions. Over and above this, we seem to find in ourselves, a Knowledge of Things *abstracted* from Matter. But the more we Labour to penetrate into the Nature of this Divine Principle, the more it seems to retire and withdraw itself from our most studious Researches.

4. In like Manner we find in ourselves various *Appetites* for good Things, and *Aversions* to evil Things: Yea, the very involuntary Motions of the Body tend to avoid the Evil and attain the Good. And the Things which are perceived by our Senses, or represented by our Imagination, so necessarily affect us, that we can by no Means hinder ourselves from having an Appetite for some, and an Aversion to others.

5. Yet frequently a more hidden and *sublime* Appetite exerts itself in our Minds: One that checks, controls, and exercises Authority over all the rest. For if we are convinced, that the Things which are pleasant, are nevertheless hurtful, the Appetite for them is over-ruled, and we find a Desire, not to enjoy, but to avoid them.

6. In order to explain these Things, philosophic Men suppose, that all the *involuntary Motions* of the Body, are performed in a Mechanical Manner, by Matter so and so modified: And that such Effects spring of Course from such Causes, according to the stated Laws of Motion.

7. As to the *Senses*, they suppose, that when the Organs of Sense are struck by any of the Bodies that surround us, and the Motion caused thereby continued thro' the Nerves to the Brain, the Soul residing there is suitably affected: God having so closely connected the Soul and the Body, that on certain Motions of the Body, (if conveyed to the Brain by Means of the Nerves) certain Perceptions of the Mind always follow: As on the other Hand, on certain Perceptions of the Mind, certain bodily Motions follow.

8. They suppose, if these Motions, which are by the Nerves communicated to the Brain, continue there
after

after the Objects are removed, the Perception of these is *Imagination* : Which, if it occurs after it has ceased, is then stiled *Memory*. Others suppose, that *Imagination* results from the Motion of the Animal Spirits, thro' those Traces which were made in the Brain, while the outward Objects were present ; and *Memory*, from the Spirits moving thro' them afresh, after some Intermission.

9. Once more. They suppose there are two Faculties in the Soul, one that is Passive, the *Understanding*, by which it perceives all the Motions of the Body, and knows and reflects on its own Operations : The other Active, the *Will*, by which we incline to good, and are averse to evil. The *Affections* are only, the *Will* exerting itself variously on various Objects.

10. To speak freely upon the Matter. I know the Body of Man is contrived with such exquisite Wisdom, that he is able, by Means of the Organs of Sense, to perceive outward Objects, to continue those Perceptions, to recall them after they are gone, and by a reflex Act to know what passes in his Mind or Body. But I know not how to account for any of these Things.

11. That the *Soul* is immaterial is clear from hence, that it is a *thinking Substance*. If it be said " God can endue Matter with a Faculty of Thinking : " We answer, no otherwise than he can endue a Spirit with Solidity and Extension ; that is, he can change Spirit into Matter : And he can change Matter into Spirit. But even the Almighty cannot make it *think* while it remains *Matter* ; because this implies a Contradiction.

12. The *Union* of the Soul and Body is another of those Things which human Understanding cannot comprehend. That Body and Spirit can't be implicated or twisted together like two bodily Substances, we know. But how two Substances of so widely different Natures, can be joined at all, we know not. All we can tell is this ; God has ordered that certain Perceptions in the Soul, should constantly follow certain Motions of the Body, and certain Motions of the Body, such Perceptions in the Soul.

13. How

13. How Mankind began is another Point, which is too hard for our Reason to determine. That Men always existed is no way probable, were it only on this Account, the late Invention of Arts. For since it appears, at what Times the most necessary Arts were invented, we cannot reasonably suppose, that Men began to exist long before that Period : Seeing if they had always existed, no Reason can be given, why these and many more Arts, were not invented long before. And yet the Accounts given of the Origin of Mankind, by the wisest of the Heathen Philosophers, are so above Measure ridiculous, that they serve as a melancholy Proof of the Weakness of barely natural Reason.

14. The scriptural Account is this. God made the Body of Man out of the Earth, and breathed into him the *Breath of Lives* : Not only an Animal Life, but a Spiritual Principle, created to live for ever. Even his Body was then perfect in its Kind ; neither liable to Death or Pain. But what the Difference was between the Original and the present Body we cannot determine.

But to form it even as it is now, no less than a Divine Power was requisite. No less could mix Earth, Water, Air and Fire, in so exact a Proportion, and then frame so many different Parts, of so various Figure, Texture and Magnitude. God alone was able to form the original Fibres ; to weave those Fibres into hollow Tubes ; to dispose these Tubes filled with their several Humours, and variously interwoven with each other into different Organs ; and of those Organs connected together in a continued Series and due Situation, to finish so complicated and wonderful a Machine as the human Body.

15. Nothing was wanting now, but that the immortal Spirit should be sent into its Habitation, to bear the Image of its Creator, and enjoy his Glory. But the Manner wherein this was done we cannot tell ; This Knowledge is too wonderful for us. And it is of no use to indulge mere Conjecture, where Knowledge is unattainable.

16. Even the present Production of the Body by Generation is what no Man can fully explain. But this
we

we know : The Female *Ovaries*, which hang on each Side the Womb, contain abundance of small Vesicles, filled with a transparent Liquor. It is supposed, that each of these contains in Miniature, all the Parts of an Human Body : That when one of them is penetrated by the Male Seed, it is rarified and expanded thereby, 'till it breaks the membranous Shell, and by the *Fallopian Tube*, falls down into the Womb. Here being slightly fastened to the Sides of the Womb, it receives Nourishment from the Mother, till the Heart is formed and begins to propel the Blood to the Extremities of the still increasing Body. When it is come to its full Size, by rolling to and fro, it tears asunder the inclosing Membranes, and having burst as it were the Prison-bars, emerges into Light.

The first Thing that appears of a Fœtus is the *Placenta*, like a little Cloud on one Side of the outer Coat of the Egg. About the same Time the *Spine* becomes visible; and a little after, the *Brain* and *Cerebellum* appear like two small Bladders. Next the *Eyes* stand prominent in the Head: then the *Punctum Salens*, the Heart beating is plainly seen, and last of all, the Extremities. When formed, the Fœtus lying in the Womb, is almost of an oval Figure. For the Head hangs down with the Chin upon the Breast. Its back is round. With its Arms it embraces the Knees, which are drawn up to the Belly, and its Heels are close to the Buttocks. Its Head is upward, and its Face toward the Mother's Belly. About the ninth Month, the Head, which 'till then was lighter, becomes heavier than any other Part. In Consequence of this, the Head falls down in the Liquor that contains it; the Feet get loose, and the Face turns toward the Mother's Back. But being now in an uneasy Posture, it struggles and brings on the Mother's Throes.

Some

* Mr. *Dodart*, nicely observing an Embryo, one and twenty Days old, found the Placenta more than half of the whole; and

Some suppose, that Millions of Animalcula swim in the Seed of Male Animals, which are so many Embryos, for which a Réceptacle only is provided in the Eggs of the Female. But all agree, that either the Male Seed or the Female Egg, contains all the Parts of the Body, so that Generation is no more than the Growth or unfolding of the Parts there delineated. But how those Seeds, whether Male or Female, are elaborated and prepared, abundantly transcends the highest reach of human Understanding.

thence concludes, the younger the Embryo is, the larger is the Placenta in Proportion to it : A plain Reason, why Miscarriages, tho' the Fetus is less, are more dangerous than regular Deliveries. For tho' the Embryo in a Miscarriage makes a Way sufficient for itself, it does not make a Way for so large a Placenta as is to follow it.

The Embryo itself was only seven Lines long, from the Top of the Head to the Bottom of the Spine where it terminated. The Thighs were not unfolded : They only appeared like two little Warts at the Bottom of the Trunk. The Arms made the same Appearance on the Shoulders. The Head was One-third of the whole Length. On this were two small black Points, which would have been Eyes. The Mouth was very big, a plain Indication that it fed thereby. There was no Eminence for the Nose : But two little, almost imperceptible Pits for the Nostrils. Always the younger the Embryo, the bigger the Head is, in Proportion to the Body. The Parts nearer the Head are likewise bigger in Proportion to the rest.

It weighed less than seven Grains, which is an extraordinary Lightness, for a Body seven Lines long. It was so soft, that no Part of it could be touched, without making a Change in its Figure. Upon opening it, Mr. *Dodart* discovered the Heart and the Right Auricle. All the other Parts in the Thorax and the lower Belly, were simple Outlines, (all Vesicular) except a Part on the Left Side, probably the Spleen.

7. If the Animalcula of which all Animals are formed, are originally in the Male, yet they never can be formed into Animals, without the Egg of the Female.

That all Animals spring from Animalcula seems probable, from the following Considerations :

1. That something may be observed in the Tread of an Egg even before Incubation, like the Rudiments of an Animal, in form of a Tadpole :

2. That after Incubation, all the Parts of the Animal suddenly appear, the *Stamina*, which existed before being then expanded. After three Days Incubation, the *Punctum Saliens* of a Chick is discovered by the naked Eye. On the fifth Day, the Rudiments of the Head and Body appear, which were before discernible by Glasses.

Glasses. After thirty Hours, we see the Head, the Eyes, the Heart, and the Carina with the Vertebrae distinct. And by Glasses we see all those Parts after forty Hours, which the naked Eye cannot discern till the fifth Day. Whence it is probable, that even the first Discovery of them by the Microscope, is not the Discovery of Part newly formed, but of those that existed before Incubation, tho' not then dilated enough to be visible.

3. That there is a near Analogy between Animals and Plants. Now we know the Seeds of these are only little Plants, folded up in Membranes. Hence we may easily infer, that Animals proceed from Animalcula folded up, till they are gradually enlarged and unfolded.

And that these Animalcula are originally in the Seed of the Male is probable. For 1. Numberless Animalcula are observed in the Seed of Animals: 2. We observe the Rudiments of a Fœtus in Eggs fecundated by the Male, but not in others. 3. The Rudiments in the Egg, both before and after Incubation, exactly resemble the Animalcula in the Seed. 4. This gives a rational Account of many Fœtus's at one Birth, especially that of the Countess of Holland. It accounts also for a whole Cluster of Eggs in an Hen, being fecundated at once: 5. This best suits the Analogy between Animals and Plants. Every Herb, and Tree bears its own Seed, a little Plant of the same Kind, which being thrown into the Womb of the Earth, spreads forth its Root and receives its Nourishment from the Earth, but has its Form within itself.

Yet that no Animal can be formed without the Egg of the Female, is evinced by the following Considerations.

1. No Animalcule can come forward, if it do not fall into a proper Nidus. So tho' a thousand should fall into one Egg, none of them would come forward, but that which was in the very Center of the Cicatrice, or Tread. And perhaps the Nidus necessary for their Formation is so proportioned to their Bulk, that it can hardly contain more than one Animalcule. This is certainly the Case in *Oviparous* Kinds. And all the Difference between the *Viviparous* and the *Oviparous* is, that in the former, the Egg is nothing but the Cicatrice with its Yolk. So that the Fœtus must draw its Nourishment from the Womb. Whereas in the *Oviparous*, the Egg itself is a Kind of Womb, containing all that is needful for the Animal, till it is hatched.

2. It is acknowledged, that the Fœtus in the Womb, is not connected with it for a considerable Time after Conception: That it is wholly loose from it, and is only a little round Egg, with the Embryo in the midst, which sends forth its umbilical Vessels by Degrees, and at last lays hold on the Womb. Hence it is plain, that the Cicatrice which nourishes the Animalcule does not spring from the Womb, but only falls into it as a fit Soil, whence it may draw Nourishment for the Fœtus.

Yet there is a Difficulty which presses equally on those, who suppose the Animal to spring either from the Male or Female Parent. It is the Case of Monsters. In a Mule, for Instance. The Body is of the Form of the Mare; whereas the Feet, the Tail and the

the Ears, resemble those of its Sire. If the Male supplied the Animalcula, one would imagine the Fetus should always be of the same Species with the Male. If the Female, it should be of her Kind : Whereas Monsters are of both : As if the main Part of the Animal lay in the Egg, and the Impregnation only conveyed or changed the Extremities.





Part the Second.

 Of Brutes.

C H A P. I.

Of Beasts.

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| 1. <i>The General Difference of Men and Beasts, as to the Structure and Posture of the Body :</i> | 6. <i>The Ears, Nose, Teeth.</i> |
| 2. <i>Their Agreement :</i> | 7. <i>The Windpipe :</i> |
| 3. <i>Their Agreement and Disagreement, as to the Head and Brain :</i> | 8. <i>Of the Vegetative and Sensitive Motions in Brutes :</i> |
| 4. <i>The Heart and Lungs :</i> | 9. <i>Of the Soul of Brutes :</i> |
| 5. <i>The Eyes,</i> | 10. <i>Of some particular Sorts of Beasts :</i> |
| | 11. <i>Some General Reflections.</i> |

1. **N**EXT to Man in the visible Creation are *Beasts*. And certainly, with Regard to the Structure of the Body, the Difference is not extremely great, between Man and other Animals. Only in this, that the *Stature* of Man is erect, and his *Form* more elegant ;
 that

that no Beast has the *Feet* of a Man, much less a *Hand* so admirably fitted for every Purpose; And lastly, that no other Animal has a *Brain*, so large in Proportion to its Bulk as Man. Concerning the prone *Posture* of their Body we may observe two Things; the Parts ministering thereto, and the Use thereof.

I. As to the Parts, it is observable, that in all these Creatures, the Legs are made exactly conformable to their Posture, as those of Man are to his Posture: and farther, that the Legs and Feet are always admirably suited to the Motion and Exercise of each Animal. In some they are made for Strength to support a vast unwieldy Body: As in the Elephant, which being a Creature of such prodigious Weight, has its Legs accordingly made like Pillars. In others they are made for Agility and Swiftmess. So Deers, Hares and several other Creatures, have their Legs very slender, but strong withal, and every Way adapted for quick Motion. In some they are formed only for Walking and Running; In others for Swimming too. Thus in the Feet of the Otter, the Toes are all conjoined with Membranes, as they are in Geese and Ducks. And in Swimming it is observable, that when the Foot goes forward in the Water, the Toes are close; but when backward they are spread out: Whereby they more forcibly strike the Water, and drive themselves forward. In others, as Moles, they are made for Walking and Digging: and in others, for Walking and Flying. In some they are made more weak, for the plainer Lands; in others, stiff and less flexible, ^b for traversing Ice and danger-

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ous

^a The Membranous Wings of a *Bat* are a prodigious Deviation from Nature's ordinary Way. And so it is in the *Virginian* Flying Squirrel; Whose Skin is extended, in the Nature of Wings, between its Fore-legs and Body.

^b The *Elk* has Legs so stiff and inflexible, that they run on Ice without slipping. And this is the Way they take in Winter, to save themselves from the Wolves.

ous Precipices. ^c In some they are shod with rough and hard Hoofs, in others with only a callous Skin. In the latter, the Feet are composed of Toes; some short, barely for going; some long, to supply the Place of an Hand; some armed with long and strong Talons, to catch, hold and tear the Prey; and some fenced only with short Nails, to confirm the Steps in running and walking.

II. As the Posture of Man's Body is the fittest for a rational Animal, so is the prone Posture of Beasts, the most useful to themselves, and the most fit for the Service they perform to Man.

2. But there is a wonderful *Agreement* between the Bodies of Men and Beasts, not only with Regard to the Structure, but also the Use of the several Parts. How they differ, will be mentioned hereafter.

3. The *Brain* in them is of nearly the same Structure and Consistence as in Man, and undoubtedly performs the same Office, secreting the Animal Spirits (if such there be) in order to Sensation and muscular Motion in every Part of the Body. The *Cerebellum* is of near the same Shape in all. But the Shape of the Brain necessarily varies, according to that of the Head. ^d

4. The

^c The *Goat*, which generally dwells on Mountains and Rocks, and delights to walk on narrow Ridges, and to take great and seemingly dangerous Leaps, has the Joints of the Legs remarkably stiff and strong. Likewise the Hoof is hollow underneath, and its Edges sharp.

^d It is remarkable, that in Man the Head is of one single Form: Whereas in the four-footed Race, it is as various as their Species. It is in some square and large, suitable to their Food, Abode, and slow Motion: In others, it is small, slender and sharp, agreeable to their swifter Motion, or to make Way to their Food, or Habitation under the Ground. And as to the Brain contained therein, how small is it in Beasts, in Proportion to what it is in Man? Another Thing no less remarkable is, The *Situation* of the Brain and the *Cerebellum*. As God has given to Man, a lofty Countenance, and has lodged in his Brain an immortal Soul, to behold and contemplate

4. The *Heart* and *Lungs* in *Beasts* are of the same Structure, with the same Apparatus of Veins and Arteries as in Men. We cannot therefore doubt but the Blood circulates in them, and Nutrition is performed as in us. Their Food also being dissolved in the Stomach, * is conveyed by the Lacteals to the *Receptacle of the Chyle*. To the Fore-part of this (in Men, the upper Part) joins the *Thoracic Duct*, which extending thro'

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heavenly Things, so as his Face is erect, his Brain is set in an higher Place, above the Cerebellum and all the Sensories. But in Brutes, whose Face is prone to the Earth, and who are not capable of Speculation, the Cerebellum, which ministers merely to animal Life, is placed above the Brain. Also some of the Organs of Sense are placed, if not above the Brain, at least on a Level therewith.

Another very great Convenience in this Position of the Brain and Cerebellum is: In the Head of Man the Base of the Brain and Cerebellum, yea, of the whole Skull is set parallel to the Horizon: by which Means there is the less Danger of the two Brains, joggling or slipping out of their Place. But in Beasts, whose Heads hang down, the Base of the Skull makes a right Angle with the Horizon. By which Means the Brain is beneath, and the Cerebellum above. And lest the Cerebellum should hereby be liable to frequent Concussions, an admirable Provision is made, by that strong Membrane, the *Dura Mater* closely encompassing it. Beside this, it is guarded in some Species with a strong, bony Fence. In the Hare, the Coney, and several others, a Part of the Cerebellum is on each Side within the *Os Petrosum*. So that its whole Mass is, by this double Stay, firmly contained within the Skull.

* But some Beasts have more Stomachs than one. And some have the peculiar Property of *chewing the Cud*. The Food after it has been swallowed is returned to the Mouth, where it is chewed over again at Leisure.

Not that this is altogether peculiar to Beasts. There have been Instances of Men who had this Property. Dr. *Stare* gives us a particular Account of one whom he knew at *Bristol*. "He begins, says he, to chew his Meat over again, within a Quarter of an Hour after Meals. This Chewing, after a full Meal, lasts an Hour and an Half. If he goes to Bed soon after a Meal, he cannot sleep, till the usual Time of chewing be over. The Viſuals returned taste more pleasantly than they did at first. Bread, Flesh, Cheese and Drink are of much such a Colour, as they would be, if mixt together in a Mortar. His Viſuals lie heavy on his Stomach, till they have passed this second Chewing. He was thus ever since he can remember. His Father does the same, but in small Quantities. What a Mercy is it, that we have not more such Instances? For how much of our precious Time would it consume?

thro' the Length of the Thorax, ends in the Vein called in Beasts *Cruralis Anterior*. The remaining Part of the Circulation, is performed in them as in Men.

5. The Situation, Number and Conformation of the Eyes in various Animals, is wonderfully adapted to their various Circumstances. In several the Eye looks chiefly forward, but so as to take in nearly the Hemisphere before it. In others, the Eyes are so placed, as to take in nearly a whole Sphere. In some they are so fixt as to look chiefly behind, so that they see their Enemy following them. So in Rabbits and Hares: Whereas in Dogs they are more forward, to look after their Prey,

Generally the Head is moveable for the Sake of the Eyes, and the Eyes themselves moveable every Way. Where it is not so, other Expedients are found, to answer the same End. Thus in some Creatures the Eyes are set at a Distance from the Head, to be moved this Way or that: As in Snails, whose Eyes are fitted to the End of their Horns, or rather of the Optic Nerves which are sheathed therein. In other Creatures whose Head and Eyes are immoveable, this is made up by the Number of Eyes. So Spiders, which cannot move their Head, have four, six or eight Eyes, all placed in the Front of the Head, (which is round) like a Locket of Diamonds,

Many Animals have Muscles to move the Eye and obvert it to the Object. Fishes have none; but for amends they have many little Protuberances finely ranged on their large, bulging Eyes, by which numberless Rays of Light are deflected from Objects above, beneath, and on either Side. Yea, some hundreds of these Protuberances are curiously ranged on the convex Eye of a Flesh-fly.

Scorpions have above an hundred Eyes; an Ephemeron-fly, full two Thousand.

In other Creatures, which have only two Eyes, the Want of Motion therein is supplied, by their Eyes protuberating into Hemispheres, each being a vast Number of Segments of a Sphere.

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The Eyes of a Cameleon resemble a Convex Glass set in a round Socket, which he turns backward and forward without stirring the Head, and commonly one a contrary Way to the other.

Lastly, Moles, living under ground, have not so much Need of Eyes as other Creatures. Yet they have Eyes, but exceeding small, far in the Head, and covered with strong Hair. When they are above Ground they can put them forth beyond the Skin, and draw them back at Pleasure.

Another Circumstance, relative to the Eye is highly remarkable. As we use various Apertures to our Optic Glasses, so Nature has made a far more compleat Provision, to admit enough, and not too much Light, into the Eyes of Animals, by the Dialation and Contraction of the Pupil. And this in divers Animals is of divers Forms, according to their peculiar Occasions. In some it is round, particularly in Man, that being the most proper Figure, for the Position of our Eyes, and the Use we make of them, both by Day and Night. In some Animals it is of a longish Form, in some transverse, with its Aperture large, an admirable Provision for their seeing side Ways, and thereby avoiding many Inconveniences, as well as an Help for gathering their Food on the Ground, whether by Day or Night. In others, that Aperture is erect, and also capable of opening wide and shutting close. The latter serves to exclude the bright Light of the Day, the former to take in the faint Rays of the Night: Thereby enabling them to see and catch their Prey, when there is no Light discernible to us.

Thus Cats can so close their Pupil, as to admit but a single Ray of Light. And again by throwing all open, they can take in all the faintest Rays: Which is an incomparable Provision for Creatures that have Occasion to watch their Prey both by Day and Night.

But beside this, in Cats and other nocturnal Animals, there is a Sort of Carpet at the Bottom of the Eye, which gives a Kind of Radiation on the Pupil, thereby enabling them to see in the Dark.

To preserve this tender Organ, many Creatures have a Membrane, which is not commonly perceived, wherewith they can at Pleasure cover the Eye, without too much hindering the Sight, being both transparent and strong, so that it is a Kind of moveable Cornea.

Providence is conspicuous in furnishing Frogs with this. For as they live in watry Places, which generally abound in Plants that have sharp Edges or Points, and as the Frog goes on, not by walking but by leaping: If he were not so furnished, he must either shut his Eyes, and so leap blindfold, or run many risques by leaving them open. But this Membrane guards the Eyes, without blinding him. And as soon as the Occasion for it is over, he draws it back into a little Cell. Many Birds also, as they must fly between Trees and Bushes, are provided with the same Membrane.

6. The Comparative Anatomy of the Ear, yields abundant Instances of the Creator's Wisdom. In Birds the outward Ear is close and covered, not protuberant, as that would obstruct their Flight. In Beasts, its Form is agreeable to the Posture and Motion of the Body, but admirably varied in the several Species, according to their various Occasions. In some, as the Hare, it is large, open and erect, by which Means that timorous, helpless Creature, is warned of the least Approach of Danger: In others it is covered, to keep out noxious Bodies. In those which are forced to mine and dig for their Habitation, it is short and lodged deep and backward in the Head. Thus Moles have no Auricle at all, but only a round Hole, between the Neck and Shoulder. And this is closed with a little Skin, which opens and shuts like an Eyelid. The Sea-Calf also, as well as Lizards, and Serpents, have an outward Ear. And the Tortoise, with most Kind of Fishes, have the Passage quite covered over.

But among all the Varieties in the Structure of this Organ, none are more remarkable than those of the Passage into the *Oss Petrosum*. In an Owl, which perches upon a Tree or Beam, and hearkens after the

the Prey beneath her, it comes farther out above than below, for the better Reception of Sounds from beneath. In a Fox, which scouts under the Prey at Roost, it comes farther out below than above. In a Pole-cat, which hearkens strait forward, it is produced behind, for the taking a forward Sound: Whereas a Hare, whose Enemy comes behind, is supplied with a bony Circle, directed backward: By means of which she receives distinctly the smallest Sound which comes that Way.

The more accurate the Sense of Smelling is in any Creature, the longer are the Laminæ in the Nostrils, and the more in Number, folded up, and crowded together, to contain more nervous Filaments, and to detain the odoriferous Particles, in their Windings and Turnings. An admirable Provision this, for the Good of many Creatures, the chief Acts of whose Lives are performed by the Ministry of this Sense. In Insects and many other Creatures, it is of great Use, in helping them to proper Places for hatching their Eggs, and breeding up their Young. And most irrational Animals, Beasts, Birds and Reptiles, do by their Smell find out their Food. With what Sagacity do some of them discover it, in the midst of Mud and Dirt? How curiously do others pick and chuse such Plants as afford them wholesome Food, (perhaps Medicine too) avoiding such as tend to hurt or destroy them? And all this principally by the Smell, together, with its near Ally, the Taste.

The various Form of the Teeth in various Creatures, is another Instance of the Divine Wisdom. How curiously are they adapted to the peculiar Food and Occasion of each Species? Thus in the Rapacious they are fitted to catch and hold their Prey; in the Herbaceous, to gather and chew vegetables. In those which have no Teeth, as Birds, the Bill supplies that Defect: together with their additional Stomach. And it is a Remark which hardly fails, all such Animals as have four Stomachs, have no Teeth at all.

There are great Varieties in the Teeth of other Animals. Trout have Teeth upon their Tongues; Cod-

Eel-fish at the Bottom of their Gullet: Crocodiles have three Rows of Teeth on the same Jaw, Sharks, four or five; Sea-devils, so called, have several Rows of moveable Teeth.

7. The Variation of the *Wind-pipe* in various Creatures is likewise observable, as it is necessary for that of the Voice. In an Hedge-hog, which has a very small Voice, it is hardly more than membranous. In a Pigeon, which has a low, soft Note, it is membranous, partly cartilaginous. In an Owl, which has a good audible Note, it is more cartilaginous. But that of a Jay (as of a Linnet) has Bones instead of Cartilages.

The Rings of the *Wind-pipe* likewise are fitted for the Modulation of the Voice. For in Dogs and Cats, which use a great many Notes, they are (as in Man) open and flexible; whereby all or any of them is more or less dilated or contracted, in order to a deeper or shriller Note. But they are one entire Ring in the *Japan Peacock*, which uses one single Note.

8. As to the *Motions* of Brutes, it is not easy to conceive, that even those of the *Vegetative* Kind, can be the mere mechanical Effects of Matter, however modified. Much less can we conceive this of their *Sensitive* Motion: For we have not the least Reason to Doubt, but the same Impressions of external Objects, raise the same Perceptions in them, as in Us. No Question they see, and hear, and smell, and taste, and feel in the same Manner as Men.

9. We cannot therefore deny, that there is something in Brutes, which perceives the Impressions made by outward Objects; and that they perform a thousand Actions, which can never be explained by mere Mechanism: Those in particular which spring from what we call *Instinct*, as the feeding and tending their Young, the building their Nests and preparing their Habitation, upon or in the Earth.

It is true, some Things in Brutes, as well as in Men, may be mechanically accounted for. But others cannot: So that we are constrained to own, there is in

them

them also some superior Principle, of whatever Kind it be, which is endued with Sense, Perception and various Appetites. For from their outward Actions we may as easily learn, as we could from those of a Man born deaf and dumb, that there are in this Principle or *Soul* two different Faculties: That of *perceiving* or *knowing*, answerable to our Understanding, and that of *desiring* and *shunning*, answerable to our Will. That this Principle is immaterial appears, from this single Consideration, it has a Power of *Self-motion*; which no Matter can have, being wholly and essentially passive.

10. It is not my Design, to enumerate the several Species of Beasts. But it may illustrate the Wisdom of the Great Creator, to give some Account of a few, several of which are not so commonly known.

The largest Land-Animal in the World is an *Elephant*. They are found only in the South of *Afric*, and in the *East-Indies*, and are generally of a dark Colour. Their Eyes are like those of a Hog. They bend their Fore-legs when they sleep; but cannot bend their Necks or turn their Heads. Their Trunk reaches to the Ground, which they can open and shut, and take up any Thing, even a Pin or a Grain of Mustard-Seed. With this they feed themselves, and in their Trunk their chief Force lies. At the Corners of their Mouth grow two large Teeth, six or seven Foot long in the Male, but not above one in the Female. They feed on Grass, Nuts and other Vegetables.

Some of them are twenty Feet in Compass, and near fourteen high. They seem to have more Sense than any other Brute, and are capable of Fidelity and strong Affection: Particularly to their Companion: So that neither the Male nor Female is ever known to make a second Choice.

The Female goes seventeen Months with her Young: They are fifty or sixty Years before they have their full Strength, are in full Vigour at much about an Hundred, and live two or three hundred Years.

A *Rhinoceros*, next to the Elephant, is the most extraordinary Animal in the *Indies*. He is equal in Height

Height to a middling Horse, but is shaped like a wild Boar: Only he is much larger, and has shorter Legs. His skin is without Hair, but so thick and hard, as to be almost impenetrable. It is so full of Scratches and Scabs, that at a Distance, they may well be taken for Scales. On his Nose he has a Horn of a dark Brown Colour, which bends backward, and is often two Foot long. He has another Horn a little above this, which never exceeds six Inches. His Eyes are exceeding small, and he only sees strait forward: Therefore he always runs in a strait Line, tearing up whatever stands in his Way. With his Horn he throws Stones over his Head to a great Distance, and even tears up trees by the Roots. He Grunts like an Hog; but when he pursues his Prey, he makes a terrible Noise. He feeds much on the Boughs of such Trees as are thick set, with tough and strong Thorns. But he prefers the Flesh of Animals, when they come in his Way. He has a natural Antipathy to the Elephant, which places all his Safety in Flight. He seldom attacks a Man, unless he is dressed in Red, a Colour to which he has a mortal Aversion. When he overtakes him, he lifts him by the Twist on his Horn, and throws him over his Head with such Violence, as breaks all his Bones, so that he never fails to find him dead when he comes to devour him. This he does by licking all the Flesh from his Bones, with his Tongue, (for he has no Teeth) which is like a File.

Another Native of the *East-Indies* is the *Camel*, one of the most serviceable Animals in the World. He kneels down to receive his Burden, and rises when he hath his accustomed Load. If he feels himself over-burthened, he will not rise, but cry till Part of it is taken off. One of them will carry a thousand or twelve hundred Weight, forty Miles a Day, for thirty or forty Days together. They have no Teeth in the upper Jaw. They will travel forty Hours, without either Meat or Drink. And nine Days without Drink: They have two Stomachs admirably contrived for this Purpose. The Gentleman who dissected one at *Paris*, found in his second Stomach several square Holes

Holes, which were the Orifices of about twenty Cavities, made like Sacks, placed between the two Membranes, which compose the Substance of the Stomach. And in these Reservoirs he contains Water enough, to serve him for so many Days.

The Bunch on his Back is not Flesh, much less Bone, but mere Hair. And when this is prest close down, he is no more hunch-backed than a Swine. They subsist on very little, which enables them to travel thro' those vast and barren Deserts. How wise is He who caused these to be Natives of those Countries, where such Creatures are absolutely necessary? A farther Instance of this is, that the *African Camel* which has still greater and more uncouth Journeys to take, is larger and stronger, and capable of carrying heavier burdens than those of *Asia*.

Another wonderful Property of Camels is, that of foreseeing the poisonous Winds, which kill in a Moment. A little before these come, they run together and cry, and hide their Noses in the Earth. And as soon as they are past, they lift up their Heads, and continue their Journey.

The *Dromedary* in most respects resembles the Camel: Only it is of a slighter Make, and instead of one Bunch on its Back, has two, about six Inches in Height. It goes frequently forty Leagues a Day: So that altho' it cannot carry above six hundred Weight yet its Swiftness atones for its Weakness. Its Feet are soft as a Sponge, and are not hurt, either by Stones or Sand. And (what is an excellent Providence) they travel best, and have the greatest Spirits in the hottest Weather.

A Creature no less remarkable, but in a quite different Way, is the *Castor* or *Beaver*. This Creature is about 4 Foot long, and 15 Inches broad. He is covered with two Sorts of Hair, one long, the other a soft Down. The Down, an Inch long, is properly his Cloathing, being extremely fine, and close laid upon the Skin. The long Hair is spread over all to preserve it from Dirt and Wet.

Whether Male or Female, it has two Bags under its Belly, which contain a liquid Substance, that congeals in Air, and affords an excellent Medicine, which we call *Castoreum*.

He has strong Teeth riveted fast in his Jaws, to cut Wood, as well as chew his Food. His fore Feet are like those of an Ape or Squirrel, to hold what he eats in his Paws. And with these he digs, softens and works the Clay or Loam for his Habitation. His hinder Feet are remarkably formed, more proper to swim than to walk with, the five Toes being joined together like those of a Goose, by a strong Membrane. His Tail is long, flattish, and covered with Scales, and constantly lubricated with Oil; because being an Architect from his Birth, he uses his Tail as a Rod, to carry his Clay or Mortar, and as a Trowel, to spread it into an Incrustation. Meantime the Scales preserve it from being hurt by the Burden; and the Oil which he squeezes from his Bags, and rubs on with his Snout, from the noxious Air and Water.

As they like to live together, they chuse a Situation near some Rivulet. They first build a Causeway, in which the Water may rise level with the first Story of their Habitation. This is built of Wood and Clay, 12 Feet thick at the Bottom, descending in a slope on the Side next the Water. The other Side is perpendicular: The Top of this is about two Foot broad. They cut their Wood, tho' as thick as one's Thigh, into Pieces, from two to six Foot long, drive them into the Earth with their Teeth, and lace them together with Boughs, closing all the Openings within and without with a strong Plaster made of Clay. If the Water increase upon them, they raise their Wall higher. Knowing their Materials are more easily brought by Water than by Land, they watch its Increase, to swim with Mortar on their Tails, and Stakes between their Teeth to the Place where they build. When the Causeway is finished, they begin their Apartments, which are Oval, and divided into three Partitions, one above another. But the Walls of these are perpendicular,

cular, and only two Foot thick: All the Wood that projects, they cut off with their Teeth: And rough-cast both the out and inside of the Work, with a Mixture of Clay and dry Grass. The first Partition, being below the level of the Dyke, is full of Water; for they love to have their hinder Part hanging in the Water. The other two are above it, so that if the Water ascend, they may ascend proportionably.

At the Bottom of their Building they strike out two Openings to the Stream; one leads to the Place where they bathe: the other to that where they ease Nature.

They associate, ten or twelve together; and proportion their House to their Number. When all is finished below, they vault the Top or Roof in an oval Form.

In Summer they feed on Fruits and Plants: In Winter, on Willow, Ash or other Wood. This they collect and store up in Time. They cut Boughs from three to six Foot long; the large Pieces are brought to the Magazine by several Beavers, the smaller, by one alone; but they take different Ways, each having his Path assigned, to prevent the Labour being interrupted. They build up their Pile with much Art, which is proportioned to their Number. A Square Pile of thirty Feet, about ten Foot deep, serves for ten Beavers. But the Wood is not piled up in one continued Heap: But the Pieces are laid across one another, with Cavities between, for the Conveniency of drawing out what they want. They always use first the Parcel at Bottom, which lies in the Water. And when it is taken up for Use, they cut this Wood into small Pieces, and convey it to their Apartment, where the whole Family come and receive their Shares.

Another Animal of a very peculiar Kind is an *Ichneumon*. It is of the Weasel Kind, with a longer and narrower Body than a Cat, something approaching to the Shape and Colour of a Badger. Its Nose is black and sharp, like that of a Ferrer. Its Colour is a yellowish Grey. Its Legs are short and each of its

Feet has five Toes. Its Tail is very long; its Teeth and Tongue much like those of a Cat. It is a very cleanly Animal, very brisk and nimble, and of great Courage. It will engage a Dog, and will destroy a Cat, by three Bites on the Throat. But it is quite inoffensive to Mankind, and is kept tame in *Egypt*, running about the House, destroying all Vermin, and playing Tricks, like Spaniels.

When wild, he cannot overtake any nimble Animal. But he makes this up by Assiduity. His Legs being short, he is not much seen; but he has a Way of concealing himself yet more, by crawling with his Belly close to the Ground, which he does all Day long. But on the least Noise (for his Hearing is exceeding quick) he starts up erect on his hinder Legs. If the Noise is made by any Reptile, Bird or small Beast, he observes where abouts it is, places his Nose directly in a Line with it, and begins to move toward it. He is silent and slow, but constant in his Approach; often stopping, to hear, or look forward, and know exactly where the Creature is: When he is got within about five Feet, he stops. Nature, which has denied him Speed, has given him Strength to leap, beyond most other Creatures. Having taken good Aim, he springs from the Place and falls directly on his Prey. Thus he deals with Beasts and Birds. But to Serpents he gives chase, and to avoid their Bite, always seizes them by the Neck.

Gesner tells, that the *Ichneumon* is not only an Enemy to Serpents themselves, but to their Eggs also; which he hunts after continually and destroys, tho' he does not feed upon them. How mercifully has God given this Animal in the Countries where those terrible Reptiles most abound! And which, without this Provision, would be so over-run with them, as to be uninhabitable.

The *Chimpanaze* is an Animal found in *Angola*, nearly approaching to the Human Figure; but of a fierce Disposition, and remarkably mischievous. In the Year, 1738, one of these Creatures were brought over

over to *England*. It was about twenty Months old. (The Parent had it in her Arms when she was killed: She was five Foot high.) It was of the Female Sex, naturally walked erect, was hairy on some Part of the Body and Limbs, and of a strong, muscular Make. It would eat any coarse Food, but was very fond of Tea, which it drank out of a Cup, with Milk and Sugar, as we do. It slept in the Manner of the Human Species, and its Voice resembled the Human, when People speak very hastily; but without any articulate Sounds. The Males of this Species are very bold, and will fight a Man, tho' he is armed. It is said, they often assault and ravish the Negro Women, when they meet them in the Woods.

There is another strange Species of *Monkey* found in the *West-Indies*, of the Size of a Fox. Its Face is raised high, its Eyes black and shining, and its Ears small and round. His Hairs are so nicely disposed all over the Body, that he appears perfectly smooth: And they are much longer under the Chin, so that they form a Kind of Beard there.

These are found in great Numbers in the Woods, and make a loud and frightful Noise. But it is very common for one only to make a Noise, and the rest to form a mute Assembly round him.

Marcgrave says, "I have frequently seen great Numbers of them, meeting about Noon: At which Time they formed a large Circle, and one placing himself above the rest, began to make a loud Noise. When he had sang thus by himself for some Time, the rest all remaining silent, he lifted up his Hand, and they all instantly joined in a Sort of Chorus. This intolerable Yell continued, till the same Monkey who gave the Signal for their Beginning, lifted up his Hand a second Time. On this they were all silent again, and so finished the Business of the Assembly."

The *Opoffum*, is about the Size of a Cat, only more corpulent, and its Legs more robust. It is of a Kind of Chestnut Colour, very bright and glossy. Its Head is long, and terminates in a Snout, somewhat like a

Hog's. The Tail is long, and much resembles that of a Rat, which it twists about with a surprizing Facility. The Legs being short, the Body is carried at no great Distance from the Ground. On the Belly of the Female, a Bag is formed by the Skin being doubled. It is not very deep, the closed Part being toward the upper Part of the Body, and the open Part toward the lower. This is covered with Fur, like the rest of the Body, so that it is not very obvious to the Sight.

It is an harmless, but likewise a defenceless Animal: And the Young of no Creature, are produced so small and tender, in respect of the Parent Animal. Therefore that Bag is extremely useful to them. They are cherished there by the Warmth of the Parent's Body, 'till toward Noon: Then they go abroad, till at the first Warning by the Evening-Cold, they retire into their Lodging again, Nor is this all the Help which it affords them. For as the tender young of the Opossum are delicate Morfels, they would be exposed to the Rage of many Animals both by Day and Night. But the Body of the Parent is a safe and ready Receptacle for them. By Day she is as watchful over her Brood, as an Hen over her Chickens. She is alarmed at the slightest Appearance of Danger, and by a Noise, which they well understand, instantly calls them into her Bag. At Night she constantly takes them in, and consults for herself and them in a very uncommon Manner. There are those among the Devourers of her young, who will climb a Tree after her. Therefore when she has climbed, to secure herself and her young still farther, she twists her Tail twice round some small Bough, and then drops from it. There she hangs with her Head downward: And whenever she pleases she recovers the Branch with her Feet by a Swing, and loosening her Tail, walks about as usual.

To enable her thus to hang, there are *Spikes* or *Hooks* in the under Side of the *Vertebrae* of the Tail. Indeed in the first three *Vertebrae* there are none; for there

there they would be of no Use. But they are found in all the rest: They are placed just at the Articulation of each Joint, and in the Middle from the Sides. Nothing could be more advantageously contrived. For when the Tail is twisted round a Bough, these Hooks easily sustain the Weight. And there is no more labour of the Muscles required, than just to bow or crook the Tail. 8

I would mention only two Creatures; more, very extraordinary, and yet but little known: *The Glutton* is frequent in the Forests of *Germany*. It is rarely seen twice of the same Figure. It is of the Weefel-kind, and is in its middle State, about the Size of a turn-spit Dog. Its Body is long, its Legs short. Its Colour is brown, with a Tinge of reddish; but its Breast and Belly are white. The Tail is long and bushy; the Head small and sharp at the Nose. The Teeth are exceeding sharp, and the Claws sharper than almost in any Creature.

This

8 It goes for Current, that the *Jackal* discovers the Lion's Prey: That each of these retains one of them, and having satiated himself, lets his Dependent feed on the Offals of his Repast.

But the Truth is, there are great Numbers of Jackals in some Woods, and when one of these sees a Stag or other large Beast, which is not a Beast of Prey, he sets up his Cry, which is like that of a Hound, and follows it. As he continues his Cry, the other Jackals that are within hearing follow likewise. And could the Creature outrun those that began the Chase, there is a continual supply; so that it cannot escape. When they have run it down, they worry it at once, and it is devoured almost in an Instant. After this the Jackals disperse, 'till another Cry invites them.

They hunt generally in the Night, and in the Parts of the East; where they are most frequent, there never is a Night but they are heard, in one Part or other of the Woods. The other Beasts of Prey understand the Sound: and frequently profit by it. If a Lion, Tyger or Leopard happens to be near, he hears the Cry, and stands upon the Watch. These large Animals are all very swift, but they are lazy, and never make long Pursuits. If the Creature pursued be far off, and run another Way, they never trouble themselves about it. But if it be near, or if it run toward the Place where the Lion is, he will dart out upon it as it goes by. And the little Animals that hunted it down, must stand by, and be content with what their Master leaves.

This is the most hungry Animal in the World, but is ill provided for catching its Prey. Most Creatures can outrun it, and itself can scarce run away from any Thing. But what he wants in Swiftneſs, he has in Climbing, which he performs to Admiration: Its ſharp Claws enabling it to run up a Tree, as faſt as on the Ground. Its uſual Place is ſome large and ſpreading Oak, choſe both for Safety and for catching its Prey. He ſquats all Day on ſome large Branch; and if nothing offers below, he preys in the Night on whatever Creatures he can find on the Tree above. Many Birds rooſt on ſuch Trees, which he climbs ſoftly to, and devours. But his favourite Food is larger Animals. He will lie many Days on a ſtanding Bough; and when any which he likes comes underneath, he drops down upon them. Hares and Rabbits ſeldom eſcape him; but he chuſes rather a Goat, or any Creature of that Size. When one of theſe comes under the Tree, he creeps from Bough to Bough, till he comes juſt over it, and then drops down. He always contrives to faſten on the Neck. In an Inſtant, he fixes both his Teeth and Claws, and lies acroſs the Neck, near the Shoulders. Here he is ſecure; and while the poor Creature runs with all its Speed, he is feeding on its Fleſh. At length it drops, and he continues eating in the ſame ravenous Manner, till from a mere Skeleton, his Back becomes round, and his Sides ſwelled out like a Tun. Still he continues to eat, till he can eat no longer. He too drops down, and lies panting for Breath. He reſembles a dead Carcaſe, ſwelled and ready to burſt with lying in the Sun: and being unable to move for a long Time, is frequently deſtroyed, and ſometimes periſhes without an Enemy.

The God of Nature ſeems to have formed the *Sloth*, to repreſent to us in a ſtrong Light, that odious and deſpicable Vice from which it takes its Name. Its Body is ſhort; its Head ſmall, and it has ſcarce any Tail. Its Fur is long, thick, and of a greyiſh Green, ſo that when ſeen on the Bough of a Tree, it appears only like an Excreſcence, or a Cluſter of Moſs. It is about the Size
of

of a Cat, but the Legs are short, as is the Neck: And its long and thick Covering, renders it so Shapeless, that it seems only an irregular Lump of living Matter. Its little and remarkably ugly Head stands close between the Shoulders. The Face has much of the Monkey-aspect. Its small and heavy Eyes, are always half shut, and it has no Appearance at all of any Ears. Its Feet are flat, and very narrow, but armed with sharp Claws, for laying hold on the Bark of a Tree, by striking deep into it.

He rarely changes his Place; and never, but when compelled by absolute Necessity. As upon the Ground it would be a Prey to every other Animal, so its constant Residence is on a Tree. Here it is safe from all Animals but those who climb these Trees, for the Birds that roost on them. The Leaves and tender Part of the Tree are its Food, and serve it for Drink as well as Meat. It never moves to another Branch, till it has devoured all the Nourishment upon that where it is stationed: Nor from one Tree to another, till the first is wholly withered and wasted.

It is observable, the *Sloth* always ascends to the Top of a Tree, only baiting as he goes, before he begins his Devastations. And this is doubtless from the instinctive Guidance of Nature. For was it to begin eating upward, when it had devoured all; it would have to climb down from the Top of a dead Tree, and would be half starved in the Journey. But this is not all. The Havock which one *Sloth* makes on the largest Tree is easily seen. For he eats not only the Leaves, but all the Buds and Bark, leaving only a dead Branch: So that unless the same Thing might happen by Accident, this would betray the Creature. It does so happen; and Trees then put on the same Form, as when they are left by the *Sloth*. But they always die at the Top first, and so gradually downward. This Animal therefore, wonderfully taught, begins its Havock at the Top. As it feeds, the Tree decays; but its Decay is in the Course of Nature. The Decay spreads downward; and when he has eaten the last of his Provision, he is near the Ground,

Ground, and has only to walk away to another Tree. But if it is at any Distance, his Motion is so slow, that he grows quite lean in the Expedition.

As the Sloth brings forth her Young in the hollow of a Tree, so is she led by the same wonderful Instinct, to conduct them to the topmost Branches, as soon as they crawl out. When she is big with Young, she climbs some old, hollow Tree; and having fixt on a convenient Spot for her Young, she climbs to the very highest Bough, and there feeds faster than usual. When she is full, she descends with unaccustomed Haste, and brings forth one, two, or three young Ones. It is well she is full Fed; for she is to support these with her Milk, till they can crawl out, without having any Supply herself. She is round and fleshy when she retires for this Purpose, but a mere Skeleton when she comes out. She crawls as well as she can, to the Part where she left off feeding, and her Young follow her. Nor will she touch any Thing in the Way, however both her Hunger and Laziness prompt her to it.

It is the most timorous of all Creatures. And with Reason; for it can neither fight nor fly. While it is journeying on the Ground, the Tread of an human Foot, shakes the Earth enough to put it into Terrors. It trembles: The Head is turned about every Way, and the Mouth is opened to Cry like a young Kitten.

Insignificant as the Creature is, there is a special Providence in the Formation and Care of it. Not designed for walking, its Claws enable it to climb, and then to hold fast in its Station. Helpless as it is, the universal Provider has assigned it a Place of Safety, where it finds Plenty of Food; and as it cannot easily seek for Drink, it has no need of any. To render it the less obnoxious to Pursuit, its Colour secures it even from View: And its amazing Instinct of feeding from the Top to the Bottom, proves a *designing* and *directing* Hand.

Before I proceed to some general Reflections upon Beasts, I beg Leave to take Notice of one Circumstance, relating to several Species of them, which is very strange, tho' very common. The *Horns* of many Animals fall
off.

off every Year, and new ones come in their Place. Our Deer drop them in *March*, and the new Horns are full grown by the *July* following. We may very justly rank this, among the most wonderful Phenomena of Nature, which yields nothing analogous to the Growth of such hard, solid Bodies, of so great a Bulk, in so short a Time. Many idle Opinions have been maintained, concerning the Cause of their falling off. The Truth seems to be this: They are a Sort of Vegetables, growing on Animals, as the Nails and Hair on Man, and Feathers on Birds. And there is some Analogy between the Growth of them, and that of Branches and Leaves in Trees. Trees commonly drop their Leaves in Autumn, because the nourishing Juice flows into them no longer. And at certain Periods, these Parts of the Animal drop off, because the Blood and Juices cease to flow into them. At this Time the hollow Part at the Root of the Horn grows hard, and the Pores, thro' which the Juices passed, grow up. And as no more Nourishment can then be carried to the Horn, it decays and falls off. 'Tis probable this Stoppage of the Pores happens, as soon as the Horns are at their full Growth. But they are so fixt to the Head that it takes a long Time for them to loosen and fall. Whereas in Leaves, their Stalks are so tender, that when the Juice ceases to flow, they presently wither and fall.

The Analogy between the falling off of Deer's Horns and the falling of Leaves and ripe Fruit, from the Tree, will receive Light from observing the Process of Nature, in the latter Case. If the Stalk from which a ripe Orange has fallen, be compared with that Part of a Deer's Forehead, from which a Horn is just fallen, it will plainly appear, that Nature has operated by the same Laws in both. The young Horns while yet soft, are full of Blood Vessels; and if cut off, especially near the Head, bleed violently. By these Vessels they are supplied with Nourishment for their Growth. But these dry up, when there is no farther Occasion for them. And hence it is, that no ill Symptoms attend the falling off of these Parts, when full grown.

So far we may give a probable Account. But who can account for this, that if a Stag be castrated while he is so young as not to have Horns, he will never have any : And if castrated afterward, while his Horns are on, he will never cast them ?

10. It remains only, to add a few Reflections. And first, what admirable Wisdom is displayed, in the *Motion* of various Animals suited to their various Occasions ? In some their Motion is swift, in others, slow, and both diversified a thousand Ways.

And first, for swift or slow Motion. This is exactly proportioned to the Occasions of each Animal. *Reptiles* whose Food, Habitation and Nests lie in the next Clod, Plant, Tree or Hole, or which can bear long Hunger, need neither Legs, nor Wings, but their vermicular Motion answers all their Purposes.

Beasts, whose Occasions require a larger Room have accordingly a swifter Motion : And this in various Degrees, answerable to their Range for Food, and the Enemies they are to escape from.

But as for *Birds*, who are to traverse vast Tracts of Land and Water, for their Food, Habitation, breeding their Young, and for Places of Retreat and Security, from various Inconveniences : They are endued with the Faculty of flying ; and that swiftly or slowly, a long or short Time, according to their Occasions. In all this the Wisdom of God appears, ordering all Things well.

Again. How admirable in the Motion of all Creatures, is the neat, geometrical Performance of it ! The most accurate Mathematician cannot prescribe a nicer Motion than that they perform, to the Legs and Wings of those that fly or walk, or to the Bodies of those that creep. Neither can the Body be more completely poised, for the Motion it is to have in every Creature. From the largest Elephant to the smallest Mite, the Body is exactly ballanced. The Head is not too heavy, nor too light for the rest of the Body, nor the rest of the Body for it. The Bowels are not loose, or so placed as to swag, over-balance, or overset the

the Body: But well-braced, and accurately distributed, to maintain the Equipoise of it: The Motive Parts also are admirably well fixt, in Respect to the Center of Gravity, placed in the very Point which best serves to support and convey the Body. Every Leg bears its true Share of the Weight. And the Wings are so exactly placed, that even in the fluid Medium, the Air, the Body is as truly balanced, as we could have balanced it with the nicest Scales.

Yet again. What an admirable Provision is made for the Motion of some Creatures, by *Temporary Parts*! Frogs, for Instance, have Tails in their Tadpole-state, which fall off when their Legs are grown out. The *Water-Newt* also when young, has four Fins, two on a Side, to poise and keep the Body upright. But as soon as the Legs are fully grown, these presently drop off.

Secondly, The *Bore* of the *Gullet* in all Creatures, is answerable to their Occasions. In a Fox, which feeds on Bones, (as in all ossivorous Beasts) it is very large. But in a Squirrel it is exceeding small, lest he should disgorge his Meat in his descending Leaps: And so in Rats and Mice, which often run along a Wall with their Heads downward.

Thirdly, In all Animals the Strength and Size of their *Stomach* are proportioned to their Food. Those whose Food is more tender and nutritive, have it smaller, thinner and weaker. Whereas it is large and strong in those, whose Food is less nutritive, and whose Bodies require large Supplies.

All carnivorous Beasts have the smallest Stomachs, as Flesh goes the farthest. Those that feed on Fruits and Roots have them of a middle Size. Sheep and Oxen which feed on Grass, have the greatest. Yet the Horse, Hare and Rabbet, tho' graminivorous, have comparatively small ones. For a Horse is made for Labour, and both this and the Hare for quick and continued Motion; for which the most easy Respiration, and so the freest Motion of the Diaphragm is requisite. But this could not be, did the Stomach lie big and cumbersome upon it, as it does in Sheep and Oxen.

Another very remarkable Circumstance is, that those Animals which have Teeth on both Jaws, have but one Stomach; whereas most of those which have no *Upper-teeth*, or no Teeth at all, have three Stomachs. For the Meat which is first chewed, is easily digested; but that which is swallowed whole, requires a stronger concoctive Power.

Fourthly, All the Parts of the same Animal are adapted one to the other. So, for instance, the Length of the Neck is always proportioned to that of the Legs. Only the *Elephant* has a short Neck: For the Weight of his Head and Teeth, would to a long Neck have been unsupportable. But then he is provided with a Trunk, which abundantly supplies the Defect. In other Beasts and Birds, the Neck is always commensurate to the Legs: So that they which have long Legs have long Necks, and they that have short Legs short ones: As may be observed in Lizards of all Kinds, and the King of them, the Crocodile. And Creatures that have no Legs, as they want no Necks, so they have none, as Fishes. This Equality between the Length of the Neck and Legs, is peculiarly seen in Beasts that feed on Grass. Their Legs and Necks are very near equal. Very near, I say, because the Neck must necessarily have some Advantage; for it can't hang perpendicular, but must incline a little.

Moreover, as these Creatures must hold their Heads down, for a considerable time together, which would be very laborious and painful for the Muscles, therefore on each Side of the Neck, Nature has placed a thick and strong Ligament, capable of stretching and shrinking again as Need requires: This, which is vulgarly called *White-leather*, extends from the Head (to which, and the next Vertebrae of the Neck it is fastened at that End) to the middle Vertebrae of the Back, to which it is knit at the other. And by the Assistance of this, they are able to hold the Head in that Posture all Day long.

Fifthly, The Parts of all Animals are exactly suited to their Manner of living. A notable Instance of this is in the Swine. His natural Food being chiefly

chiefly the Roots of Plants, he is provided with a long and strong Snout; long, that he may thrust it to a convenient Depth in the Ground, without Offence to his Eyes; strong, and conveniently formed, for rooting and turning up the Ground. And besides, he has an extremely quick Scent, for finding out such Roots as are fit for him. Hence in *Italy*, the usual Way of finding Truffles, or Subterraneous Mushrooms is by tying a Cord to the Hind-leg of a Pig, and driving him before them into their Pastures. They then observe, where he stops and begins to root: and digging there, they are sure to find a Truffle. So in Pastures where there are Earth-nuts, tho' the Roots are deep in the Ground, and the Leaves are quite gone, the Swine will find them by their Scent, and root only in the Places where they grow.

Another Instance of like Nature we have in the *Porpes* (antiently wrote *Porc-pesce*, that is, *Swine-fish*) which resembles the Hog, both in the Strength of his Snout, and in the Manner of getting his Food. For the Stomach of one of these when dissected, was found full of Sand-Eels, which lie deep in the Sand, and cannot be gotten but by rooting or digging there.

That very Action, for which we look upon Swine as unclean Creatures, namely, wallowing in the Mire, is designed by Nature for a good End; Not only to cool their Bodies, (which fair Water would do as well) but also to suffocate and destroy Fleas, Lice, and other Insects, which are troublesome and hurtful to them. For the same Reason, Poultry and divers other Birds bask themselves in the Dust, in hot Summer Weather.

A farther Instance of the Fitness of Animals for their Manner of Living, we see in the *Ant-Bear*: which has not only a sharp Head and Snout, but also a narrow, and toothless Mouth. Their Tongue is as big as a Goose-quill, round, and in some, about two Foot long. Therefore it lies doubled in a Channel, between the lower Parts of the Cheeks. This when hungry they thrust out, being well moistened, and lay upon the Trunks of Trees: And when it is covered with

Ants, suddenly draw it back into their Mouths. If the Ants lie deep, they dig up the Earth with their long and strong Claws, with which their Fore-feet are armed. So are they fitted for this Diet and no other!



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|---------------------------------|-------------------------------------|
| 1. <i>Of their Motion :</i> | 6. <i>Generation.</i> |
| 2. <i>Brain :</i> | 7. <i>Of some particular Sorts</i> |
| 3. <i>Organs of Sense :</i> | <i>of Birds :</i> |
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1. **T**HE Species of Birds are exceeding numerous. These have *Feathers*, which they expand in order to fly; the fine Branches of which lie so close together, that little Air can insinuate itself between them. Now when the Column of Air on which a Body rests is specifically heavier than the Body, it remains suspended in the Air; if it be lighter, the Body sinks. Hence the larger Space a Body circumscribes, the more easily does the Air sustain it. Consequently the same Bird which sinks when the Wings are closed, is sustained when they are expanded. To this also the Motion of the Wings contributes: (As a Body while moving swiftly, will swim in Water, which immediately sinks, if that Motion ceases.) And so do the Feathers, with which their Bodies are clothed, which increase their Bulk, but not their Weight in the same Proportion.

The Parts of Birds chiefly concerned in flying, are the Wings and the Tail. By the first, the Bird sustains and wags himself along. By the second he is enabled, to keep his Body steady and upright, particularly

cularly in ascending and descending. It is by the Largeness and Strength of the Pectoral Muscles, that they are qualified for flying. In Men there are scarce a seventeenth Part of the Muscles of the Body. In Birds they considerably outweigh all the other Muscles together. And this Circumstance alone, the Want of suitable Muscles, makes all Human Attempts to fly, void and vain.

In flying, the Bird first bends his Legs and leaps from the Ground; then opens the Joints of his Wings, so as to make a right Line, perpendicular to the Sides of his Body. Being now raised and strongly vibrating his Wings, the Air re-acts, as much as it is acted upon, and so protrudes his whole Body. But in recovering his Wing for fresh Strokes, it has a great Resistance to overcome. To elude this, the bony Part of the Wing, into which the Feathers are inserted, moves Sideways with its sharp End foremost, and the Feathers follow it like a Flag.

All Birds have near their Tail a little Bag, which contains Oil, to moisten their Feathers. Geese have two Glands for the Secretion of this: Other Birds only one. In this are divers little Cells, ending in two or three large ones, lying under the Nipple of the Oil-bag. This Nipple is perforated, and being prest by the Bird's Bill, emits its Oil.

In all Birds that fly much, the Wings are placed in the very best Manner, to balance their Bodies in the Air, and to give as swift a Progression, as they are severally capable of. Otherwise they would reel and fly unsteadily; as we see they do, if we destroy the Equipoise, by cutting one of their Wings.

And what Nicety may we observe, in a Part no more considerable, than the *Vanes* of the Flag-feathers of the Wing! 1. The Edges of the exterior or narrow Vanes bend downward, but the interior, wider Vanes upward. By this Means they catch hold and lie close to each other, when the Wing is spread; that not one Feather may miss its full Force and Impulse upon the Air. 2. Equal Nicety is observed in the very sloping the Tips of the Flag-feathers: The interior

Vanes are neatly sloped away to a Point, toward the outward Part of the Wing. The Exterior (at least in many Birds) are sloped toward the Body. And in the Middle of the Wing, the Vanes being equal are but little sloped. So that the Wing, whether open or shut, is as neatly sloped, as if constantly trimmed with a Pair of Scissars.

The *Vane* consists not of one continued Membrane, because if once broke, it would not easily be repaired: But of many *Laminae*, which are thin, stiff, and something resembling a thin Quill. Toward the Shaft of the Feather (especially in the Flag-feathers of the Wing) these *Laminae* are broad and of a semicircular Form, which serves for Strength, and for shutting them close together, when Impulses are made on the Air. Toward the outward Part of the Vane, they grow slender and taper. On their under Side they are thin and smooth; but their upper-outer Edge is parted into two hairy Edges.

As curiously made are the Feathers in the Wing, and no less curiously placed, exactly according to their several Lengths and Strength; and these again are lined, faced and guarded with *Covers* and *Secondary Feathers*, to keep the Air from passing thro' and so eluding the Impulse.

Lastly, How admirably wrought are the *Bones* of the Wing, very strong, but light withall: The *Joints*, which open, shut, and move every Way, as occasion is; and the various *Muscles*, all suited to the Motions which they minister to.

Next to the Parts for Flight, let us view the *Legs* and *Feet*, which minister to their other Motions; both made light, for their easier Passage thro' the Air, and the latter, some with Membranes for swimming, some without, for steady going, for perching, for catching and holding their Prey, or for hanging by the Heels, to gather their Food: The *Legs*, all curved, for their easy perching or roosting, as also to help them upon their Wings, in taking their Flight. In some they are long, for wading and searching the Waters; in others,

others, if need be, remarkably short. And how wisely are they placed! In all somewhat out of the Center of the Body's Gravity. But in such as swim, more than in others, for the better rowing their Bodies, as also to help them in diving.

Geese and *Ducks*, their Bodies being made for Swimming, have their Wings too placed out of the Center of Gravity, nearer the Head: But the extending the Neck and Head in Flight, balances the Body upon the Wings: Which is another excellent Use (beside searching for Food) of the long Necks of these Birds.

But in the *Heron*, whose Head and long Neck (altho' tucked up in Flight) overbalances the hinder Part of the Body: the long Legs are extended, both to counterpoise the Body, and to supply what is wanting in the Tail.

It has been supposed, that the Flying of Birds is analogous to the Rowing of Vessels. But it is a Motion of quite another Kind. Oars are struck toward the Stern: Whereas Birds do not vibrate their Wings, toward the Tail, but waft them downward. Nor does the Tail cut the Air (as the Rudder does the Water) at right Angles, but horizontally. It likewise keeps the same Situation, which Way soever the Bird turns.

It is not therefore by the Tail, that most Birds turn to the right Hand or the Left, but by the Wings. They turn to the Right, by beating the Air with the left Wing alone toward the Tail: To the Left, by beating it with the Right Wing. Thus Pigeons changing their Course toward the Left, labour with the right Wing, scarce stirring the other.

Birds

* It is a remarkable Use which is made of Pigeons, in the Eastern Countries. They are trained up in *Turky* and *Persia*, to carry Expresses: being first used to short Flights, afterwards to longer, till at length they will return from the farthest Part of the Kingdom. Yea, if they are brought hoodwinked twenty or thirty Miles, nay sixty or an hundred, they will find their Way in a very little Time, to the Place where they were bred. Every Balhaw has a Basket of these Pigeons, bred at the Seraglio: one of which he dispatches thither on any emergent Occasion, with Letters braced under her Wings. This proves a more speedy Method, as well as

Birds with long Necks have another Way of altering their Course, by only inclining their Head and Neck this or that Way.

Birds rarely fly up or down perpendicularly, but rather in a crooked Line. In ascending directly, the Natural and Artificial Tendency would counter-act each other. In descending directly both would concur, and endanger too precipitate a Motion.

Only the Hawk stoops directly to seize its Prey: Whereas other Birds in descending, retard the Motion by keeping their Wings expanded, and at the same time stretching out their Feet and Legs.

There is no flying Animal, but has Feet as well as Wings; because there is not Food, or at least not Food sufficient for them, to be had always in the Air. But if there were, yet such Birds could take no Rest; for having no Feet, they could not perch upon Trees. And if they alighted on the Ground, they could not raise themselves again, which Birds that have short Feet can hardly do. Beside, they would want Means of Breeding, having no Way to lay their Eggs, to sit, hatch or brood their Young. As for the Story of the *Manucodonta* or *Bird of Paradise*, said to have no Legs it is now discovered to be a Fable.

This Bird is a Native of *Arabia*, it is one of the lightest Birds that is known; and its Feathers are so disposed, that with a small Motion of its Wings, it can float upon the Air. And indeed it lives mostly there, seldom standing on its Feet, except to sleep. Hence many have supposed, that it lives wholly in the Air, and was sustained without Food. Those who brought them into *Europe*, finding this increased their Price, tore their Legs off, and pretended they never had any.

It is indeed much on the Wing, like the Swallow, and like this, feeds on flying Insects as it flies. And the *Arabian* Insects being larger and stronger than ours, its

faster, than any other. For one of these Birds will carry a Letter from *Babylon* to *Aleppo*, which is thirty Days Journey, in forty-eight Hours.

its Beak is proportionably stronger, than that of the Swallow.

It is not strange, that a Bird so light, and having very long Feathers, should lie upon the Air, almost without moving. But the strength of its Legs, and the Sharpness of its Claws, shew it is designed both for standing and tearing its Prey.

Before we conclude this Head, it may be observed, that all the Parts of Birds are fitted for their Use of flying. First, as the Muscles of the Wings are peculiarly strong, so the under Side of them is made concave, and the upper convex, that they may be the more easily lifted up, and the more strongly strike the Air. Then the Trunk of their Body somewhat resembles the Hull of a Ship, the Head, the Prow; which is generally small, that it may the more readily cut the Air, and make Way for the Body. Add to this, that the Bodies of Birds are small in Comparison of Beasts, that they may be more easily supported by the Air. And they are not only small, but of a broad Figure, that they may be buoyed up the better. They are also hollow and light: Yea, their very Bones are light. For even those of the Legs and Wings have ample Cavities: By this Means also they become rigid and stiff: It being demonstrable, that a hollow Body is more stiff and inflexible, than a Solid one of equal Substance. The Shafts also of the Feathers are either empty, or filled with a light and spongy Matter. And their Webs consist of two Rows of contiguous Filaments furnished all along with Hooks on each Side, whereby catching hold of one another, they stick fast together.

As to their Tails, altho' it is true, as was observed, that all Birds whose Tails are pointed and end in a right line, turn themselves by their Wings and not their Tails, yet in those that have forked Tails it is otherwise. Thus it is manifest to Sight, that the Forked-tail'd Kite, by turning her Train Sideways, raising one Horn, and depressing the other, turns her whole Body. And doubtless the Tail has the same Use in Swallows, who have all forked Tails, and make more sudden Turns in the Air than any other Bird.

But Feathers must in Time wear out. Therefore Nature has provided for the renewing them yearly. To lighten Birds still farther, they have large Membranes extending to the Bottom of their Bellies, into which the Air is received, where, by the Heat of the Body it is expanded into twice or thrice the Dimensions of the external Air. And this they can either compress by the Muscles of the Abdomen, or expire, more or less, in order to their descending swifter or slower, in what Degree they please.

As to the *Brain* of Birds, whereas in Men the *Cortical* Part of the Brain is outermost, in Birds it is innermost, and the Membrane that covers the upper Ventricle is *Medullary*. The Ventricles likewise are situated above, near the upper Part of the Skull.

Perhaps before we proceed, it may be well to premise one general Observation, that the Structure of Birds is in many Respects different from those both of Men and Beasts; having several Parts which these want, and wanting others which they have. Besides, there are great Variations in the Contrivance of Parts which are common to both: All wisely adapted to their different Conditions and Manner of Life.

Parts peculiar to Birds are 1. The *Bill*; 2. The *Membrane* to draw over the Eyes, 3. *Feathers* and *Wings*. The Parts wanting in Birds, are 1. *Teeth* and *Lips*, 2. The *Bladder*, which they do not need, as they drink no more than just to moisten their Food. Variations in the Parts of Birds from those of Men and Beasts are 1. In the *Ear*, which is of a very peculiar Make, 2. In the Division of the *Aorta*, 3. In the *Spinal-Marrow*, which is divided into two in the Middle of the Back, 4. In the *Bones*, which are all hollow, 5. In the *Heart*, which has a fleshy Valve at the Mouth of the *Vena Cava*, 6. In the *Lungs* which are strongly joined to the Back, for the greater Convenience of Flight, 7. In the *Stomach*, Birds have two or more, to supply the Want of chewing, 8. In the *Legs* and *Feet*, 9. In their *Tails*, 10. In their *Pectoral Muscles*, which are the strongest of all, whereas in Man the *Crural Muscles* are the strongest, 11. In the *Brain*,

as was before observed, 12. In the *Bronchia*, which extend to the very Bottom of the Abdomen, so as to contain a large Quantity of Air, 13 In the *Ovaries*, which in Birds are single, and fastened on their Back.

The *Ears* of Birds differ much from those both of Men and Beasts. There is almost a direct Passage from Ear to Ear: So that if the Drum be pricked in either Ear, Water poured in at one Ear, will run out at the other. And what is still more remarkable is, they have a small winding Passage, that opens into a large Cavity, running betwixt two Skulls, and passes all round the Head. The Upper of these Skulls, is supported, by many hundreds of small, thread-like Pillars: Which have another Use also, to break their Sound, and hinder its making a confused Echo.

This Passage between the two Skulls is much larger in Singing-Birds than in others. So that a Person who has been shewn this, may hereby know them from all others.

The other Organs of Sense are nearly the same in Birds as in other Animals. Only there is a Difference in the Organ of *Smell*. The Nostrils lie on each Side of the Beak in the inner Part whereof, beside the Tube which reaches to the Lungs, there are little Tubes, continued from the Membranes and Substance of the Brain. And these seem to be the Organ of Smell. Only two Nerves pass thro' the *Os Cerebrum* to the Beak: Lest if there were more Perforations, as in other Animals, too much Air might flow into the Brain.

3. The *Bill* of Birds is peculiarly remarkable. In the first Place, it is neatly shaped for piercing the Air. In the next, it is hard and horny, to supply the Want of Teeth, and also in some Measure, of an Hand. Its hooked Form is of great Use to rapacious Birds, in catching and holding their Prey; and to others, in climbing, and in taking and comminuting their Food. ^b

Its

^b Parrots have their Bills nicely adapted to these Services, being hooked, for climbing and reaching what they want, and the lower

Its extraordinary Length and Slenderness is of Use to some, to search for their Food in Moorish Places: ^c As its Length and Breadth is to others, to hunt and search in muddy Places. ^d The contrary Form, a thick, short and Sharp edged Bill is as useful to all other Birds, who must husk the Grains they swallow. But it would be endless to reckon up all the Shapes, and commodious Mechanism of all: The Sharpness and Strength of those that have occasion to perforate Wood and Shells; ^e the Slenderness and Neatness of such, as pick up small Insects: The cross Form of such as break up Fruits; ^f the compressed ^g Form of others, with many other curious Forms, all suited to the Occasions of the several Species.

In

Jaw so exactly fitted to the Hook of the Upper, that it will break the Food, as other Creatures do with their Teeth.

^c As to *Woodcocks* and *Snipes*, who hunt for Worms in Moorish Ground, and likewise suck the unctuous Humour out of the Earth. So also the Bills of *Curlews*, and other Sea-fowl are very long, to enable them to hunt for Worms, &c. in the Sands.

^d *Ducks*, *Gulls*, and divers other Species of Birds, have Bills both long and broad, whereby they are enabled to quaffer in the Water or Mud, till they find their Food.

^e The *Green Woodpecker*, and all *Woodpeckers* have strong and sharp Bills, curiously made for digging Wood. An even Ridge runs along to the Top of the Green Woodpecker's Bill; as if an Artist had designed it at once for Strength and Neatness.

Woodpeckers have also a Tongue, ending in a sharp, bony Rib, dented on each Side, which they can at Pleasure shoot out to a great Length, and thrust into the Holes, Clefts and Crannies of Trees. They strike them likewise into Ant-hills, and fetch out the Ants and their Eggs. Moreover they have short, but strong Legs, and their Toes stand two forward, two backward; a Disposition which is particularly convenient, for the climbing of Trees. In this they are likewise assisted by the uncommon Stiffness of the Feathers of their Tails, and by their bending downward, whereby they are fitted to serve them as Props to lean on.

^f The *Cross-Bill*, whose Bill is thick and strong, with the Tips crossing each other, readily breaks open Fir-cones and other Fruits, to come at and feed on the Kernels. And undoubtedly the crossing of the Bill was designed for this very Service.

^g The *Sea-pye* has a long, sharp, narrow Bill, compressed Sideways, and every Way adapted, to the raising Limpets from the Rocks, which are its chief, if not only, Food.

In the *flat-billed Birds*, as *Ducks*, there are three Pair of Nerves, which come down between the Eyes into the upper Bill, whereby they are enabled to smell and find out their Food, in the Mire or Water. The like have been observed in several round-billed Birds, but so small as to be scarce discernible. Only in the *Rook* they are discernible enough: And it is remarkable that these, more than any other round-billed Birds, grope for their Meat in Cow-dung and the like.

Concerning *Birds of Prey*, it is observed, 1. They commonly fly single, but not always; Vultures fly in Troops, after an Army, fifty or sixty together. 2. That the Females are both larger, stronger, and of more Courage than the Males: Nature so ordering, because they must procure Food, not only for themselves, but also for their Young.

4. Of their *Lungs* it is observable, that they are not only larger in Proportion than those of Beasts, but they admit the Air, both above and beneath, by which means they become far lighter.

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^h A *Duck* is furnished with a peculiar Structure of Vessels, which enables it to live some Time under Water. Yet she cannot live without Air. One that was put into the Air-pump, and the Air exhausted, seemed to bear it better for a few Moments, than any other Fowl. But in less than two Minutes her Head fell down, and she appeared dying, 'till revived by letting in the Air.

A young, callow *Duck* being tried in the same Manner, was near Death in less than two Minutes. It is observable both of them swelled extremely, on pumping out the Air. It not being intended, that Water-Fowl should live in an exceeding rarified Air, but only continue under Water, they are qualified for this, but not at all for the other.

Yet that *Ducks* can live almost any where, we may learn from the blind *Ducks* of the *Zerchintzer Lake* in *Carniola*, a Territory of *Austria*. This communicates with another Lake under Ground in the Mountain *Savornick*, and fills or empties itself according to the Fulness or Emptiness of that. The Waters of the Upper Lake, when it empties, run off by large Holes in the Bottom. The *Ducks* which are very plentiful in the Water, are often carried down with it into the subterraneous Lake. In this many of them undoubtedly perish; yet some remain alive. But they lose their Sight and their Feathers: And at the next filling of the Lake, both they and vast Numbers of Fish are thrown up with the Water. They make a strange Appearance

It is likewise remarkable, that whereas in other Animals the Lungs are loose and have much Play, in all Birds they adhere to the Thorax, and have little Play. This is a good Provision for their steady Flight. Also they want the *Diaphragm*, and instead thereof have divers large Bladders, made of thin, transparent Membranes, with pretty large Holes, out of one into the other. These Membranes serve for Braces to the Viscera, as well as to contain Air. Toward the upper Part, each Lobe of the Lungs is perforated in two Places with large Perforations; whereof one is toward the outer, the other toward the inner Part of the Lobe.

in their naked State; and for Want of Sight are easily caught. In about a Fortnight they recover their Sight and their Feathers, and are then as big as common Wild-ducks. At their first coming up, their Stomachs are full of small Fishes, and something resembling Weeds. It seems therefore, they were not quite blind, when in their dark Habitation, but could see by that small Quantity of Light, to search for and find their Food.

Nor is it in this Lake only, that these Ducks are found. They are frequently thrown up, after great Rains, at a Hole in a Mountain, near the Town of *Laon*, in the Isle of *France*. The Water then gushing out with great Violence, brings these blind and bald Creatures with it. And their Frequency and Cheapness, from the vast Quantities which are thrown out, makes them esteemed no Variety.

The Bodies of *Duchers* or *Looms* are admirably fitted for diving. Being covered with a thick Plumage, and the Surface of it so smooth, that the Water cannot penetrate it. Hereby their Bodies are defended from the Cold, the Water being kept at a Distance; and are so poised, that by a light Impulse, they easily ascend in it. Again, their Feet are situate in the hindmost Part of their Body, so that shooting them backward and striking the Water upwards, they plunge themselves down with great Ease, and move forward therein. Their Legs also are made flat and broad, and their Feet cloven into Toes, with appendent Membranes on each Side. By this Configuration they easily cut the Water, and are drawn forward, to take their Stroke backward: And by this, their Feet being moved to the Right or Left, serve them as a Rudder to turn under Water. How they rise above Water is not determined: Whether by their natural Lightness, or by striking against the Bottom, in the Manner of a Leap, or by some peculiar Motion of their Legs. That they dive to the Bottom is undeniable. For in the Stomachs both of the greater and lesser Kind, we find much Grass and other Weeds; and in the lesser Kind, little else. Yet both prey upon Fish; and their Bills are straight and sharp, for the easier striking their Prey.

Lobe. Thro' these Peforations the Air has a Passage into the fore-mentioned Bladders; so that by blowing into the Windpipe, the Lungs are raised, and the whole Belly blown up. This doubtless is a Means to make them more or less buoyant, as they take in more or less Air: And so answers the Design of the Air-bladder in Fishes.

In general we may observe, whatever is peculiar in the Wings, Bills, and every other Part of Birds, on a close Inspection will be found exactly suited to their Wants. They are a Set of Implements nicely proportioned to their Manner of Life. To instance in a few, *Sparrows* and most small Birds, are supported by the little Grains they find up and down. They have no Effort to make, to obtain their Food, or break it in Pieces, and therefore have a small Bill, as well as short Necks and Legs, which are sufficient for their Purposes. But the *Woodcock*, *Snipe*, *Curlew*, and many other Birds, seek their Food deep in the Earth or Slime. Therefore they are provided with a long Neck and Bill, and with these they dig and search and want for nothing. The *Woodpecker*, who lives in a quite different Manner, is as differently formed. His Bill is very long, solid and strong: his tongue is sharp, and extremely long; beside which, it is armed with little Points, and covered with Glue toward the Extremity. He has short Legs, two Talons before, two behind, and all very crooked. All this Equipage suits his Manner of Living. His Food is Worms or Insects, that live in the Heart of Branches of Trees, or under the Bark of old Wood; frequently they are sunk very deep, under the Bark of large Billets. The Woodpecker has hooked Claws, to grasp these Branches; and a strong, and pointed Bill, to find out by darting it up and down, what Parts of them are rotten. When he has found out these, he with his Bill, shatters the Bark and Wood. He then sends forth a loud whistling Cry, into the Cavity, to alarm the Insects and put them in Motion. Next he darts in his Tongue, and by the small Points which rise out of it, and the Glue that covers it, draws out whatever lodged there.

The *Heron*, on the Contrary, mounts aloft. His Legs and Thighs are very long, and bare of Feathers. He has a great Length of Neck, and an enormous Bill, very sharp and jagged at the End. What reason can be assigned for a Figure, which at first Sight seems so extravagant? He feeds on Frogs and small Shell-fish, as well as other Fish which he finds in Fens, or Bogs, or near the Shores of Rivers. He wants no Feathers on his Thighs, to walk thro' Water and Slime; but he needs very long Legs, to run in the Water, along the Shores, whether the Fishes resort for their Food. A long Neck and Bill qualify him for pursuing and seizing his Prey at some Distance: And the Jaggs of his Bill enable him to hold the Fish, which would otherwise slide away. In fine, his large Wings, which seem incommodious to a Bird of so small a Body, are absolutely needful for his making so great Movements in the Air, and conveying such Burdens to his Nest, which is frequently two or three Leagues distant from the Place where he fishes.

The Imperfections therefore which we imagine we discover, in this, (as in many other Animals,) in Reality belong only to our own Understanding: And all our Censures of the Works of Nature, are in Truth, only so many Indications of our own Ignorance.

5. The *Stomach* (especially of granivorous) Birds, is of a peculiar Structure. First, there is a glandulous Receptacle, wherein the Grains are kept for some Time. They are then received into another Stomach, consisting of two Muscles, and a callous Membrane. One of these moves obliquely downward, and the other upward. Hereby the Shell of the Grain is broke, and the Meal expressed and mixt with proper Juices. The Aliments thus prepared fall into the Bottom of the Stomach, where they are purged again from the Refuse: To which End that Part is a little raised, that the Corn may not pass out too soon. There is also a Partition, which divides what is already digested from the rest.

As Birds have no Bladder, in the room of Urine, a whitish Excrement is discharged from the Kidneys into the Rectum.

6. The

6. The *Generation* of Birds is now well known. In the *Ovary*, placed between the Liver and the Backbone, a great Number of Yolks are contained; one of which when impregnated, passes thro' the *Oviduct* into the Womb, where it receives the *White* and the *Shell*, and remains 'till it comes to its full Size. The Parent then broods over it, 'till the Young being gradually formed, perfected and quickened, bursts the *Shell*.

Under the *Shell* of an Egg lies the *Common Membrane*, adhering closely to it, except at the bigger End, where a little Space is left between them. This Membrane contains two *Whites*, each inclosed in its own Membrane. In the Middle of the inner *White* is the *Yolk*, inclosed likewise in a separate Cover. The outer *White* is *Oval*, the inner *Round*, (as is the *Yolk*) and of a more viscid Substance.

At each End is a *Chalaza*, a white, dense Body, consisting of three little Globules, like Grains of *Hail*, (so the Word signifies) all joined together. These serve both to knit the several Membranes together, and to keep the Liquors in their proper Places and Position.

About the Middle of the small End of the *Yolk*, is a little yellowish Bladder, like a Vetch, called the *Cicatricula* or *Eye* of the Egg. This contains an Humour, in and out of which the young Bird is generated. The *White* serves it for Food, 'till it becomes big; then the *Yolk*, and likewise after it is hatched. For even then a good Part of the *Yolk* is lodged in its Belly, as in a Storehouse, and being conveyed thence by the *Intestinal Duct* into the Bowels, serves it instead of Milk.

An Egg, *improperly* so called, is that, of the whole whereof the Animal is formed. Such are the Eggs of Flies. *Proper* Eggs, when excluded, need no external Nutriment. Of proper Eggs, some are *perfect*, that is, have all the Parts above described, while in the *Ovary* or *Womb*: Some *imperfect*, which have them not, 'till after they are excluded: As those of Fishes, which assume a *White* in the Water.

An Egg not impregnated by the Male, will never breed Young, but always putrify. One impregnated contains the Rudiments of the Bird, even before Incuba-

tion. By the Microscope we see the plain Carina or Spine of it swimming in the Middle of the Cicatricula, consisting of fine, white Threads, which Incubation gradually perfects.

The *Air-Bag* is very small in a new-laid Egg, but becomes larger, when the Egg is kept. The Yolk is specifically heavier than the White. Hence its smaller End is always uppermost, in all Positions of the Egg.

After Incubation the Air-bag gradually extends, till near the Hatching, it takes up a Third of the Egg. By Incubation the White becomes thinner and more turbid, especially near the Air-bag, where it is first consumed. Then it lessens towards the sharp End of the Egg, till nothing is left but a white, chalky Substance. The White of an impregnated Egg is as sweet all the Time of Incubation as that of a new-laid Egg. They are only unimpregnated Eggs, vulgarly called *Wind-Eggs*, which putrify and stink.

The Yolk also remains fresh and uncorrupted, all the Time of the Incubation. It is deprest in the Middle, as the Chick grows, and is soon brought into a Form, not much unlike that of a Horse-shoe, in the Middle of which the Chick lies.

Not long before the Chick is hatched, the whole Yolk is taken into the Abdomen.

The Eye or Tread, in which the Chick lies, is soon enlarged by Incubation, and rises to the upper Part of the Egg. The Heart and umbilical Vessels, are some of the first Parts, which we are able to distinguish.

The Embryo is seen at first like a small Worm. Then its Carina or Spine appears, with the large Prominences that afterward shew themselves, to be the Brain and Eyes. The other Bowels seem hanging from the Spine. Then the Chasm of the Mouth is discovered. The Extremities sprout out. The Bowels are gradually covered with the Teguments. At last the Beak, Nails and Feathers are seen. When all its Parts are formed, the Chick is always found lying on its Side, with its Neck bent forward, the Head covered with the upper Wing, and the Beak placed between the Thighs.

The

The Birds which nourish their Young, have commonly very few. On the Contrary, those whose Young feed themselves when they first see the Day, have sometimes eighteen or twenty at a Brood. This Prudence could only spring from Him, who regulates all Things to the best Advantage. Were those who provide for their Young to have so numerous a Brood, both the Parents would be Slaves, and yet the Young but ill accommodated. Whereas the Mother, who only marches at their Head, without nourishing them, can conduct Twenty as well as Four.

But when they first make their Appearance, what Care do the Parents take, till their Young can subsist without them? Of those that feed their Young, the Linnet and the Nightingale then labour like the rest. Sometimes one Parent goes in Quest of Provisions, sometimes the other, and sometimes both. They are up before the Sun. And the Food they have procured, they distribute with great Equality, giving each a Portion in its Turn, before ever they feed one Bird twice.

And this Tenderness for their Offspring is so strong, as even to change their Natural Disposition. Follow the Hen when she is the Parent of a Family, and she is no longer the same Creature. She is no longer ravenous and insatiable. If she finds but a Grain of Corn or Crumb of Bread, she never touches it herself, but calls her Troop, by a Note they well understand; and divides it among them. She is no longer timorous, but at the Head of her Young, will spring even at the stoutest Dog.

When the Turkey-hen appears at the Head of her Young, she sometimes utters a mournful Cry, and they immediately run under Bushes, Furz or whatever presents itself. She looks upward, and repeats her Cry: Which is occasioned by her seeing a Bird of Prey, tho' so distant, that he appears to us, only as a dark Point under the Clouds. But he no sooner disappears, than she utters another Cry, which revives all her Brood. They run to her, flutter their Wings, and shew all the Tokens of Joy. Now who apprizes her of an Enemy, that never yet committed any Act of Hostility in the Country? And how is she able to discover him, when at so
great

great a Distance & How are her Family instructed, to understand her different Cries, and regulate their Behaviour accordingly? What Wonders are these which are daily obvious to our View, tho' we treat them with Inattention?

When almost all Birds produce their Young by Incubation, yet the Scripture gives us one Exception. *The Ostrich leaveth her Eggs in the Earth, and forgetteth that the Foot may crush them—because GOD hath deprived her of Wisdom, neither hath he imparted to her Understanding, Job xxxix. 14, &c.* In which Words we may observe, 1. This anomalous Way of Incubation, by the Heat of the Sun, 2. The singular Care of the Creator, supplying the Parent's Want of Care, so that the Young are fed and bred up notwithstanding, even in those large and barren Deserts: 3. The Instinct of irrational Animals, is expressly ascribed to GOD. *She forgetteth, because GOD hath deprived her of Wisdom, and not imparted unto her Understanding:* That understanding, that natural Instinct, which most other Creatures are endued with.

An amazing Degree of natural Instinct or Understanding, GOD has imparted to *Birds of Passage*. They fly in Troops, often in the Form of a Wedge, with the Point foremost. They steer their Course thro' unknown Regions, without either Guide or Compass. And they are peculiarly accommodated for their Flight, by the Structure of their Parts.

In the Act of Migration, it is highly remarkable, 1. That they *know* (as the Scripture speaks) *their Appointed Times*, when to come, when to go. *Appointed* by whom? Surely by the Great Creator, who has imprinted on their Nature an Inclination, at such a Time to fly from a Place that would obstruct their Generation, or not afford Food for them and their Young, and betake themselves to another Place, which will afford all that is wanting.

It is highly remarkable, 2. That they know whither to go, and which Way to steer their Course! That they should be directed yearly to the same Place, perhaps to a little Island, as the *Basse* in *Edinburgh Frith*. How come Land-birds to venture over a vast Ocean,

of

of which they can see no End? And how do they steer their Course aright to their several Quarters, which before the Compass was invented, Man himself was not able to do? They could not possibly see them at that Distance. Or if they could, what should teach or persuade them, that that Land is more proper for their Purpose than this? That *Britain*, for Instance, should afford them better Accommodations, than *Egypt*, than the *Canaries*, than *Spain*, or any other of the intermediate Places?

But it has been commonly supposed, that several Birds are of this Number, because they disappear in Winter, which really are not: Cuckoos, for Instance, and Swallows: For neither of these ever cross the Seas. Cuckoos lodge all the Winter in hollow Trees, or other warm and convenient Cavities. And Swallows have been found in vast Quantities, clung together in a Lump, like Swarms of Bees, but utterly cold and senseless, even in Ponds that have been cleaned out, hanging under the Water.

7. The largest of Birds is the *Centur* of Peru. The Body is as big as that of a Sheep. Its Wings extended are fifteen or sixteen Feet from Point to Point. It is never seen in Forests, because it would not have Room to fly, but frequents the Sea-shore and the Banks of Rivers. Nature to allay their Fierceness has denied them the Talons given to Eagles, tho' they are of the Eagle-kind. However their Beak is strong enough to tear off the Hide, and rip up the Bowels of an Ox.

What a Blessing is it to Mankind, that there are but few (just enough to keep up the Species) of this Monster in the feathered Creation! And into what can we resolve this, but the wise and over-ruling Care of an adorable Providence?

The smallest of all Birds is the *Humming-bird*, but of the most beautiful, lively Colours of any. It flies very swiftly, and in flying makes a Noise like the Humming Bee. It can sustain itself a long Time on the Wing, and in that Posture, thrusts its little Beak into the Flowers, the Juices of which it sucks and feeds on. As it has no Food but this, there is no keeping it alive, but all die that are taken.

They

They are naturally very gentle; but when they nestle they are very fierce, and will chase the largest Birds that come near their Nests. This they can easily do as their swift Flight enables them to attack their Adversary in any Part, and yet fly on, but they generally attack the Eyes, and other tender Parts. They fly to and fro, backward and forward, in an Instant, often with their Bodies perpendicular. And frequently so swift that you cannot observe them, nor know what Course they take, but by the Noise they make in cutting the Air.

Their Egg is of the Size of a Pea. They make their Nest chiefly of Cotton, or the Down of Plants intermixt with a few Hairs, and a little fine Moss. And these they commonly fasten to the Branch of an Orange or Lemon-tree, where they are well covered by the foliage, and the larger Branches.

The *Indians* make Pictures with the Feathers of these Birds, which are so brightly coloured, as to vie with the finest Paint, and so thin, that they look like Colours on Canvas.

The *Stork* is a Bird of Passage, and goes away toward Winter to the Southern Countries. It has a very long Beak, and long red Legs. It feeds on Serpents, Frogs and Insects. As it seeks for these in watry Places Nature has provided it with long Legs. And as it flies to the Nest with its Prey, its Bill is strong and jagged, to hold fast what it has taken. She likewise digs with her Bill into the Earth for Snakes or Adders, which she carries to her Young. Most of her Feathers are white. She lays but four Eggs, and sits for thirty Days.

But what renders this Bird most remarkable is, its steady Love to its Parents. It never forsakes them when they are old, but tenderly feeds and defends them, as long as they live.

The following Adventure of a tame Stork some Years ago in the University of *Tubingen*, seems to shew a Degree of Understanding, which one would scarce expect in the Brute-Creation. This Bird lived quietly in the Court Yard, till Count *Victor Gravenitz*, then a Student

Student there, shot at a Stork's Nest, adjacent to the College, and probably wounded the Stork then in it. This happened in Autumn, when foreign Storks usually leave *Germany*. The next Spring a Stork was observed on the Roof of the College, which after a Time came down to the upper Gallery, the next Day, something lower, and at last, by Degrees, quite into the Court. The tame Stork went to meet him with a soft cheerful Note, when the other fell upon him with the utmost Fury. The Spectators drove him away; but he came again the next Day, and during the whole Summer, there were continually Skirmishes between them. The Spring following, instead of one Stork, came four, and attacked him all at once. A surprizing Event followed. All the Turkies, Ducks and Geese, that were brought up in the Court ran together, and formed a Kind of Rampart round him, against so unequal a Combat. This secured him for the present. But in the beginning of the third Spring, about twenty Storks suddenly alighted in the Court and before the poor Storks Life-guards could form themselves, or the People come to his Assistance, they left him dead on the Spot: Which none could impute to any Thing but the Shot fired by Count *Victor* at the strange Stork's Nest.

The *Pelican* somewhat resembles a Swan. The Body is as large, the Neck nearly as long, the Legs are short, and the Feet are black, broad and webbed in the same Manner. It is also of a whitish Colour, only the Tips of some of his Feathers are black. It is much in the Waters. It has a most horrid Voice, like that of a Man grievously lamenting.

Its Beak is above a Foot in Length, and the Point is very sharp. The upper Part is formed as in other Birds; but the Lower is unlike every Thing in Nature. It is made of two long, flat Ribs, with a tough Membrane connected to one and the other. This reaches also to the Throat, and is very broad and loose, so that it can contain a vast Quantity of Provision.

It frequents both fresh and salt Waters, and feeds on Fish. Yet its favourite Residence is in wild, remote Forests, where it may remain undisturbed; and it easily flies,
having

having strong Wings, backward and forward. Here it builds and breeds its Young: And hence it is stiled "The Pelican of the Wilderness." Hither she is to bring Food for a numerous Brood; and for this End the Bag at her Throat is provided. In this she stores what she has caught, and flying away to her Nest, feeds her Young out of her Storehouse. And hence arose the Tale, so commonly believed, of her feeding them with her own Blood.

In the Year 1745, a Pelican brought from the Cape of Good Hope, was shewn in London. The Pouch at its Throat was so large, that the Keeper put his Head into it.

That which in *Iceland* they call the *Down-bird*, is very remarkable. It is a Species of Duck, but covered with fine, soft, downy Feathers. The Drake is full as large as a Goose, but the Duck considerably smaller. They abound all over *Iceland*, but particularly the Western Part, on Account of the Islands off the Coast, where chiefly they build their Nests. They build them with the Down they pull from their Breast: They lay four green Eggs, as large as a Goose. The Inhabitants then take away both the Eggs and the Nest. The Ducks go to work again, pull more Down from their Breasts, and lay four Eggs more, which are again taken away by the Inhabitants. This does not however discourage the Duck. She builds a third Nest, and lays four more Eggs: But the Drake is now obliged to supply the Down, the Duck having none left. They now let her hatch her Young: For if they disturb her the third Time, she builds no more that Year, nor ever returns to the same Place. When the Young have left the Nest, they take it a third Time, and so have two Sets of Eggs, and three Parcels of Down from the same Nest.

The *Bat* seems a Medium between Bird and Beast. But it comes nearer to the Latter. They lay themselves up and sleep for the Winter Months, in the dryest Parts of Caves. There fixing their Talons in the Roof, they cover their Bodies with their Wings, and hang perpendicularly in great Numbers, but so as not to touch each other.

8. I have now only to add a few Reflections.

And

And, 1. That Birds should all lay Eggs, and not bring forth live Young, is a clear Argument of Divine Providence, designing their Preservation thereby. For if they had been Viviparous, had they brought any Number at a Time, the Burden of their Womb must have been so great and heavy, that their Wings would have failed, and they become an easy Prey to their Enemies. And had they borne but one at a Time, they would have been bearing all the Year.

2. Since it would have been many Ways inconvenient to Birds to give suck, and yet inconvenient, if not destructive to the new-born Chick, to pass suddenly from Liquid to hard Food, before the Stomach was strengthened and able to digest it, and before the Bird was accustomed to use its Bill and gather it up, which it does at first very slowly and imperfectly: Therefore Nature has provided in every Egg a large Yolk, which serves the Chicken a considerable Time instead of Milk. Meantime it feeds by the Mouth a little at a Time, and that more and more, till the Stomach is strengthened to digest it.

3. Birds that feed their Young in the Nest, tho' they bring but one Morsel at a Time, and have perhaps seven or eight, which all at once, with equal Greediness, hold up their Heads and gape; yet never mistake, never omit one, but feed them all by Turns.

4. Tho' Birds cannot number, yet are they able to distinguish many from few. And when they have laid as many Eggs as they can cover they give over, and begin to sit. Yet they are not determined to such a Number: They can go on and lay more at their Pleasure. Hens, for Instance, if you let their Eggs alone, lay fourteen or fifteen, and give over. But if you withdraw their Eggs daily, they will go on, to lay five Times that Number. This holds not only in domestic Birds, but also in the Wild. A Swallow, when her Eggs were withdrawn daily, proceeded to lay nineteen.

5. It is remarkable, that Birds, and such other oviparous Creatures as are long-lived, have Eggs enough conceived in them at first, to serve laying for many Years, allowing such a Proportion for every Year, as will suffice for one or two Incubations: Whereas In-

sests, which are to breed but once, lay all their Eggs at once, be they ever so many.

6. How exceeding speedy is the Growth of Birds that are fed by the old ones in the Nest! Most of them come to near their full Bigness, within the short Term of a Fort-night: An admirable Provision, that they may not lie long, in that helpless Condition, exposed to the Ravine of any Vermin, and utterly unable to shift for themselves.

7. What amazing Care do the Parents take, for the hatching and rearing of their Young? First they seek out a secret and quiet Place, where they may be undisturbed in their Incubation. Then they make their Nests, every one, after his Kind, that their Eggs and Young may be soft and warm: And those so elegant and artificial, as no Art of Man can imitate.

"I have seen, says Mr. Ray, the Nests of an Indian Bird composed of the Fibres of some Roots curiously platted together, which they hang on the End of the Twigs of Trees over the Water, to secure their Eggs from Apes, Monkeys and other Beasts." After they had laid their Eggs, how diligently do they sit upon them, scarce giving themselves Time to go off, to get them Meat? When the young are hatched, how diligently do they brood over them, lest the Cold should hurt them? All the while labouring hard to get them Food, and almost starving themselves, lest they should want. Moreover, with what Courage are they inspired, so as to venture their own Lives in Defence of them? The most timorous as Hens and Geese, daring then even to fly in the Face of a Man. And all these Pains are bestowed upon those that will render them no Thanks for it! And they are bestowed just so long as is necessary. For when the Young is able to shift for itself, the Old retains no such Affection for it, but will beat it indifferently with others.

8. It is another Proof of a superintending Providence, that all Animals are produced, at the most convenient Time of the Year, just when there is Food and Entertainment ready for them. So Lambs, Kids and many other living Creatures, are brought into the World in the Spring, when tender Grass and nutritive Plants are provided for their Food. The like may be observed concern-
ing

ing Silk-worms, whose Eggs are hatched just when the Leaves of the Mulberry-tree appear: The Aliment being soft and tender, while the Worms themselves are so, and growing more strong and substantial, as the Insects increase in Bulk and Vigour.

9. A still farther Proof hereof we have in the various *Instincts* of Animals, directed to Ends which they know not, As 1. All creatures know how to defend themselves, and offend their Enemies. All know what their natural Weapons are, and how to make Use of them. A Boar knows the Use of his Tusshes, a Horse of his Hoofs, a Cock of his Spurs, a Bee of her Sting. Yea a Calf will make a push with his Head, even before any Horns appear. 2. Those Creatures which have not Strength to fight, are usually swift of Foot or Wing, and are naturally inclined to make Use of that Swiftmess, and save themselves by Flight. 3. Every Creature knows and shuns its natural Enemy, as a Lamb does the Wolf, and Partridge or Poultry, Birds of Prey. And they make Use of a peculiar Note, to warn their Young of their Approach, who thereupon immediately run to Shelter. 4. As soon as ever it is brought forth, every Animal knows its Food. Such as are nourished with Milk immediately find their Way to the Paps and suck. Whereas those which are designed for other Nourishment never make any such Attempt. 5. Birds that are Pin-toed, or Whole-footed are naturally directed to go into the Water. So Ducklings, tho' hatched and led by a Hen if she brings them to the Brink of a River or Pond, presently leave her and go in, tho' they never saw any such Thing before; and tho' the Hen clucks and calls, and does all she can to keep them out. 6. Birds of the same Kinds make their Nests of the same Materials, laid in the same Order, and exactly of the same Figure, so that by the Sight of the Nest one may certainly know what Bird it belongs to. And this, tho' living in distant Countries, and tho' they never saw any Nest made; that is, altho' they were taken out of the Nest and brought up by Hand. Nor were any of the same Kind ever known to make a different Nest, either for Matter or Fashion.

I would add a little farther Improvement of some Particulars mentioned before.

What Master has taught Birds, that they have any need of *Nests*? Who has warned them, to prepare them in Time, and not to suffer themselves, to be prevented by Necessity? Who hath shewn them how to build? What Mathematician has given the Figure of them? What Architect has taught them to chuse a firm Place, and to build on a solid Foundation? What tender Mother has advised them to cover the Bottom with a soft and delicate Substance, such as Cotton or Down, and when these fail, who has suggested to them that ingenious Charity, to pluck off as many Feathers from their own Breast, as will prepare a soft Cradle for their Young?

Again. What Wisdom has pointed out to each Kind a *peculiar Manner* of building? Who has commanded the Swallow to instance in one, to draw near to Man, and make Choice of his House for the building her Nest, within his View, without Fear of his knowing it, but seeming rather to invite him to a Consideration of her Labour? Nor does she build like other Birds, with Bits of Sticks and Stubble, but employs Cement and Mortar: And that in so firm a Manner, that it requires some Pains to demolish her Work. And yet in all this, it has no other Instrument to make Use of but a little Beak!

Yet again. Who has made the Birds comprehend that they must hatch their Eggs by sitting upon them? That this Necessity is indispensable: That the Father and Mother could not leave them at the same Time; and that if one went abroad to seek for Food, the other must wait till it returns? Who has told them, the precise Number of Days, this painful Diligence is to cost? Who has taught them, to assist the Young in coming out of the Egg, by breaking the Shell for them? Yea, and advertised them of the very Moment, before which they never come?

Who has taught several of the Birds that marvellous Industry, of retaining Food or Water in their Gullet, without swallowing either, and preserving them for their Young, to whom this Preparation serves instead of Milk?

Is it for the Birds, O Lord, who have no Knowledge thereof, that thou hast joined together so many Miracles? Is it for the Men who give no Attention to them? Is it for those who admire them, without thinking of Thee? Rather is it not thy Design, by all these Wonders, to call us to Thyself? To make us sensible of thy Wisdom, and fill us with Confidence in thy Bounty, who watchest so carefully over those inconsiderable Creatures, two of which *are sold for a Farthing*.

But pass we from the Industry of Birds, to harken for a Moment to their Musick: The first Song of Thanksgiving which was offered on Earth, before Man was formed. All their Sounds are different, but all harmonious, and all together compose a Choir which we cannot imitate. One Voice however more strong and melodious I distinguish above the rest. On Inquiry I find it comes from a very small Bird. This leads me to consider the rest of the Singing Birds. They likewise are all small: The great ones having an harsh and disagreeable Voice. Such an amend is made to these weak, little Creatures, for their Defect of Strength!

Some of these little Birds are extremely beautiful, nor can any Thing be more rich or variegated than their Feathers. But it must be owned, that all Ornament must give Place to the Finery of the *Peacock*: upon which God has plentifully bestowed all the Riches which set off the Rest, and lavished upon it with Gold and Azure, all the Shades of every other Colour. This Bird seems sensible of its Advantage, and looks as if it designed to display all its Beauties to our Eyes, when it stalks along, and expands that explendid Circumference, which sets them all in open view.

But this pompous Bird has of all others that are kept tame, the most disagreeable Cry, and is a Proof, that there may be a shining Outside, when there is little Substance within.

In examining the Feathers of the Rest, I find one more Circumstance very observable. The Feathers of Swans and other Water-fowl, are proof against the Water. And accordingly they continue dry, tho' the Creature swim or dive ever so long. And yet neither our Eyes

nor all our Art can discover, wherein they differ from others.

I know not how to conclude this Chapter, without adding a few more Reflections.

All the Universe is replenished with Life: and every Part of it, with its proper Animals. But would one expect to see them in the Air? Nothing seems more Natural to our Eyes: But nothing is more astonishing to our Reason. The Fact is certain, and yet might seem to be altogether impossible. A Bird in Flight, is a Mass raised aloft, in Spite of the Gravity of the Air, and the Tendency of all Bodies to the Earth. This Mass is raised, not by any foreign Force, but by a Movement suited to the Purpose of the Creature, and which sustains it in the Air, for a considerable Time, with a peaceful Vigour.

Again. In the whole Kingdom of Birds, none have more than two Wings, and yet they all fly in a different Manner. Some launch away by repeated Springs; Others glide thro' the Air with an even Motion. These always skim over the Earth; those soar up to the Clouds. Some know to diversify their Flight, by a straight, oblique or circular Motion: To suspend their Bodies, and continue motionless in an Element lighter than themselves: After this, to start into an horizontal Motion, and then dart either to the Right or Left, wheel into a contrary Tract, remount, and then precipitate themselves like a descending Stone: In a Word, they transport themselves, without Opposition, or Hazard, wherever their Necessities or Pleasures call them.

The Structure of their Nests, the Care with which they attend their Eggs, the Mechanism of the Egg itself, and the Birth and Education of their Young, are equally astonishing. See the perfect Similitude that appears in all the Nests of Birds of the same Species, the constant Difference between the Nests of one Species and another! Together with the Neatness and Precautions which all of them observe. One Species builds its Nest on the Top of Trees; another on the Ground, under a Canopy of Grass: But always with a Shelter, either of Herbs, or a Branch, or a double Roof of
Leaves,

Leaves, down which the Rain slides, without entering the Opening, which lies concealed below. The outward Part of the Nest is made of solid Materials, Thorns, Reeds, Clay, or compact Mass: The inner of softer Materials, closely interwoven, so as to keep out both Winds and Insects. But each Species have a peculiar Taste. When the Building is compleated, some hang the Inside with a Tapestry of Feathers, or quilt it with Wool or Silk.

How amiably does this display the Wisdom of Him who furnished Man with Reason, which extends to every Thing around him, and inspired Animals with an Imitation of it, limited indeed to a few Points, but admirable in that Limitation? For who informed the Bird, that she should lay Eggs, and want a Nest to lodge and nourish them with genial Heat? That this Heat would not be centered round the Eggs, if the Nest were too large? And that were it smaller, it would not be capable of containing all the Young? Who has taught her not to miscalculate the Time, or lay her Eggs, before she has compleated her Nest?

The same Wisdom will more fully appear, if we observe what the Egg contains, with the Manner how the Young is there formed, and how it issues from its Confinement.

The Yolk lies in the Heart of the Egg, inclosed in the first Membrane, which is surrounded by the Second. Near the Center of the Egg are the Ligaments that sustain the Yolk, which is contained in a peculiar Membrane. A second Membrane incloses the first White; a third and fourth encompasses the whole. The Shell is formed last of all, out of the Salts evacuated from all the Humours of the Body, which the Heat gradually fixes and consolidates, to serve a double Purpose, first that it may be excluded without crushing the Contents; secondly, to defend the tender Young, till it is thoroughly formed, and ready to forsake the Egg.

Under the Membrane which surrounds the Yolk, is a white Speck, which is the Seed of the Chick, in Miniature. If the smallest Portion of the vital Spirit be infused into it from the Male, by a Process of which we have

have no Idea, in the Instant the Chick receives Life, and the whole Substance is in Motion. If it is not infused, the Egg may indeed be laid, but it never comes to a living Creature.

The Pulsation of the Heart bears some analogy to the Pendulum of a Clock, from whose Vibrations the whole Machine derives all its Motions. The Moment the Heart begins to beat, the Animal is alive, and receives by the umbilic Duct, the Nourishment which it transmits to the other Vessels, whose Branches distribute it to the whole Body. All those little Canals, which were flat before, are now swelled and enlarged. The whole Substance imbibes a proper Aliment, and the Chick begins to grow.

In this Situation of the Speck out of which it is formed, one Circumstance is highly remarkable. This minute Particle which is lodged on the Film that includes the Yolk, is always near the Center of the Egg, and toward the Body of the Dam, in order to be impregnated with a necessary Warmth. But in how admirable a Manner is this effected? The Yolk is sustained by two Ligaments, which fasten it on each Side to the common Membrane, that is glued on the Shell. A Line drawn from one Ligament to the other, would not pass thro' the Middle of the Yolk, but above the Center, and cut the Yolk into two unequal Parts, so that the smaller Part, which contains the Seed, is of Necessity raised toward the Belly of Birds that sit: The other Part as necessarily subsides, so that let the Egg turn as it will, the Young receives no Hurt, but still enjoys a Warmth, that puts all about it in Motion. So it feeds at ease, first on the White, which is more thin and delicate, and afterwards on the Yolk, which affords a more substantial Nourishment. When his Bill is hardened, and he grows uneasy at his Confinement, he pecks and breaks the Shell and issues out, fully replenished with the Yolk, which nourishes him a little longer, till he is strong enough to raise himself upon his Feet, and can march about to look for Provisions.



1. Of Fishes: their Conformation:
2. Their Brain:
3. Organs of Sense:
4. Gills or Lungs:
5. Heart:
6. Of Shell-fish: Of the Generation of Fish:
8. Of some particular Sorts of Fish:
9. Some General Reflections.

1. **T**HE Variety of Fishes is abundantly greater than even that of Birds. A World of Wisdom appears in the Structure of them, and their Conformation to the Element they are to reside in. Their Bodies are either thin, or long and slender, for their more easy swimming and dividing the Water. They are cloathed suitable to their respective Circumstances, the Dangers they are exposed to, and the Motions they are to perform. The Center of Gravity is placed, in the fittest Part of the Body, which is smooth, sharper before and tapered off, in order to make its Way the more commodiously. They have Fins made of gristly Spokes, firmly connected by Membranes, which they are able to contract or dilate, like a Woman's Fan. These are furnished with Muscles for Motion; but their chief Use, is to balance and keep the Body upright; as appears, in that when they are cut off it wavers to and fro. Their *Air-bladder*, which they can either dilate and fill with Air, or contract and empty at their Will, enables them to rise or sink, or sustain themselves to any Height in the Water at their Pleasure. The great Strength by which they dart themselves forward, like an Arrow out of a Bow, lies in their *Tails*; their Fins meantime, lest they should retard their Motion, being held close to their Bodies. And therefore almost all the Muscular Flesh they have, is bestowed upon the Tail and Back. Their Eyes are peculiarly formed to correspond with all the Convergencies and Divergencies of Rays, which the Variations of the watry Medium, and the Reflections thereof may occasion.

2. It is observable in all, that tho' their Heads are much larger in Proportion to their Bodies, yet their *Brain*, is considerably less, than that of other Animals. It consists of only two small Ventracles, placed in the Forepart of the Head.

3. Their *Organs of Sense* do not much differ from those of other Animals. But in their *Eyes* this is peculiar, that they are quite Spherical, and that the Optic Nerves in coming from the Brain, cross each other: Whereas in other Animals, they incline a little to each other, but do not meet. ¹ It was formerly believed, they did not *hear* at all. But from later Experiments, there is Reason to believe, that several Species of them do hear, tho' but in a low Degree. Over the two Holes in their Head which serve for *Smelling*, a fine Membrane is spread, by which Means they can open and shut them at Pleasure; a Contrivance highly necessary for Creatures that live in the Water.

4. Some Fishes have *Lungs*. But in the greater Part the Place of them is supplied by *Gills*. As we take in and throw out the Air by our Lungs, so they take in the Air, mixt with the Water by their Mouth, and throw it out by their Gills.

There is always much Air inclosed in Water. This the Gills separate from it, and present to the Blood, as it is presented in the Lungs of other Animals. Each Gill contains a great Number of bony Laminae, consisting of an Infinity of bony Fibres, that sustain the innumerable Ramifications of the Veins and Arteries, which present the Blood extremely subdivided, and as it were, each Globule by itself to the Water: Between these Laminae, thro' the whole Contexture of the Gills, are an Infinity of very narrow Passages, which receive and divide the Water taken in by the Mouth, into minute Particles. Then the Air, its Prison-doors being in some Measure

¹ A protuberant Eye would have been inconvenient for Fishes, by hindering their Motion in so dense a Medium. And their continually brushing thro' the Water, would have been apt to wear their Eyes. Therefore their Cornes is flat. But to make amends for this, and for the Refraction of Water, different from that of Air, the wise Creator has made their Chrystalline Spherical, which in other Animals is more flat.

Measure opened, escapes and joins the Blood of all the little Arteries.

The Gills have an alternate Motion of Dilatation and Compression. When they dilate, the Water is taken in; when they contract, it is driven out. It seems, that in the Instant of Contraction, the Air express'd from the Water is forced into the Blood-vessels. It is the same, as to our Lungs. The Air enter them at the Time of Inspiration, but is received into the Blood at the Time of Expiration only. So that the Water which is taken in by the Mouth of Fishes, when strip of its Air, is carried off by the Gills. Meantime the Air which thus gained is distributed first to those fine Ramifications of the Arteries, which are expanded upon the Gill throughout, and then to the Veins inosculated therewith. And Fishes can no more live without a constant Supply of this, than Land Animals can.

The Gills in all Fishes are Eight, Four on each Side. The lower Gill is always smaller than the rest. The other three, on each Side are gradually larger to the Top-one, which is always the largest. Each of these is formed of a bony Substance, bent into the Shape either of a Semicircle, or a Bow. On the convex Side of this, there is a sort of Plumes or Leaves, each of which consists of a double Row of bony Lamellæ, formed like so many Sickles, and fix'd to the convex Side of the Bow by Means of the Membrane wherewith it is covered.

These Lamellæ have one Part convex, the other concave. The concave Part of each Lamella is applied to the convex Part of the next opposite Lamella. Every Lamella is invested with a fine Membrane, which receives the Ramifications of the Blood-vessels. Every Gill has an Artery, a Vein and a Nerve. The Gills receive the Blood which is thrown from the Heart into the Aorta, and derive it to the utmost Parts of the Lamelle, from whence it returns by Veins which distribute it throughout the Body.

5. In most Fishes the Heart is like that in other Animals. But in some it has only one Ventricle; which necessarily occasions a Difference in the Manner, where in the Blood circulates. In some also the Blood is not red but clear

clear and transparent. In others, especially Shell-fish, besides the Arteries and Veins, there are open Tubes, which convey the Water to the farthest Part of them: Probably that they may find no Want of Water, when they continue some Time on Shore.

6. It has long been supposed that all Shells, as well as the Animals in them, arose wholly from the Egg. But it is now found by various Experiments, that the Shells of Snails (and probably of all other Animals) are formed of a Matter which perspires from their Bodies, and then condenses round them.

'Tis certain, all Animals perspire and are encompassed with an Atmosphere which exhales from them. Snails have nothing peculiar in this Respect; unless that their Atmosphere condenses and hardens about them, and forms a visible Cover for the Body, while that of other Animals evaporates. This Difference may arise from the different Substance perspired, that from Snails being viscous and stony. This is no Supposition, but a Matter of Fact, proved by numerous Experiments.

Tho' therefore the Shell serves for an universal Bone, yet it does not grow like other Bones, by a Juice circulating within itself, but by an external Addition of Parts, laid over one another.

But the *Re production* of the Shells of some Fish, yea, and of the Parts contained therein, is far more strange and unaccountable, than their first Production. This is particularly observed in Crabs and Lobsters. Lobsters cast their Shell yearly, sometime after Midsummer. In the Room of the old, a new, thin Shell is immediately prepared by Nature, which in less than Eight Days, acquires almost the same Degree of Hardness as the other.

The Legs of a Lobster consist of five Articulations. When any of these Legs break, which frequently happens, the Fracture is always near the fourth Joint, and what they lose is precisely re-produced in some Time after: Four Joints shooting out, the first whereof has two Claws, as before.

If a Leg be broken off purposely at the fourth or fifth Joint, it is constantly re-produced: But very rarely, if at the first, second or third Joint. What is still more surprizing is, that upon visiting the Lobster, which was maimed

maimed in these barren Articulations, at the End of two or three Days, all the other Joints are found broken off at the Fourth, which he has undoubtedly done himself.

The Part re-produced is perfectly like that broke off, and in a certain Time grows equal to it. Hence it is, that Lobsters have often their two big Legs unequal. This shews the smaller Leg to be a New one. If a Part thus re-produced is broken off, there is a second Re-production. The Summer, which is the only Time when Lobsters eat, is the most favourable Time for this. It is then performed in four or five Days; otherwise it takes eight or nine Months.

The common Crab-fish has its abode from twenty to forty Fathom Water. They herd together in distinct Tribes, and have their separate Haunts for feeding and breeding, and will not associate with their Neighbours. This has been tried, by marking a Crab, carrying it two or three Miles, and leaving it among other Crabs. This Crab has afterward found its Way home, and been caught in its old Abode.

This Creature too can break off its own Limbs. If when it is laid on its Back, one of the outer Joints of a small Leg be bruised, he shews Uneasiness, by moving it about. Afterward he holds it quite still, in a direct and natural Position, without touching any Part of the Body, or of the other Legs with it. Then on a sudden with a gentle Crack, the wounded Part of the Leg drops off. If an Hole be pierced in the Great Leg, the Effect will be the same; and the large Limb is thrown off in the same Manner, only with greater Violence. A Mucus then overspreads the Wound, which presently stops the Bleeding; and a small Leg is by Degrees produced, which gradually attains the Size of the former. Nature has given this singular Power to these Creatures, for the Preservation of their Lives in their frequent Quarrels. In these, one Crab lays hold of the Claw of another, and crushes it in such a Manner, that it would bleed to Death, had it not the Power, of giving up the Limb and healing the Wound.

One of the most extraordinary Kinds of Shell-fish is the *Animal-Flower* in *Barbadoes*. In the Parish of St.

Luty, on the North Side of the Island, there is a high rocky Cliff fronting the Sea, near the Bottom of which is a large Cave. This opens into another Cave, the Bottom of which is a basin of Water. In the midst of this Basin is a Rock, always covered with Water: On the Sides of which, a few Inches below the Water, are seen at all Times of the Year, issuing out of little Holes, what have the Appearance of finely-radiated Flowers, in Size, Colour and Shape greatly resembling a common Marygold.

If you attempt to pluck one of these, as soon as your Fingers come within two or three Inches of it, it contracts, closes up its Border, and shrinks back into the Hole of the Rock. But if left undisturbed for a few Minutes, it issues again, and soon appears in full Bloom. This might induce one to believe, that it was no other than an aquatic Sensitive Plant.

But on a nearer Inspection we may discern four dark-coloured Filaments, rising from the Center, moving with a quick and spontaneous Motion, and frequently closing, to seize its Prey, much like the Claws of a Lobster. So that the seeming Flower is really an Animal; and its Body, which appeared to be the Stalk of the Flower, is black, about as big as a Raven's quill.

It seems the vivid, yellow Colour of its Feelers, is absolutely necessary to procure its Food. The Water in the Cave having no Motion, cannot bring any Food to them. Therefore the Creator has endued this Creature with a Quality which may allure its Prey. For bright Colours invite many aquatic Animals, as the Flame of a Candle does Flies.

7. As to the *Generation* of Fishes, some of them are Viviparous, other Oviparous. The Womb and Ovaries of most Fishes, are not unlike those of Birds. The Female casts out innumerable Eggs, in the Sea, in Lakes, in Rivers. Great Part of these are devoured by the Males. The rest are hatched by the Warmth of the Sun, and the Young ones immediately swim away, without any help from the Parent.

Sea-Tortoises lay their Eggs on the Sea shore, and cover them with the Sand. It is not uncommon to see a great
Number

Number of young Tortoises rise out of the Sand, and without any Guide or Instructions, march with a gentle Pace toward the Water. But the Waves usually throw them back upon the Shore, and then the Birds destroy the most of them. So that out of two or three hundred of them it is seldom that ten escape.

It seems at first View, that Nature, in this Instance, charges herself with unnecessary Expence. But a little Reflection shews the contrary. We do not complain of the Fertility of an Hen, which frequently lays above two hundred Eggs in one Year: Altho' it may be, that not one Chick is hatched out of all these. The Design of the Author of Nature is plain; not barely to preserve the Species, but at the same Time, to provide Man and other Animals with an excellent Food. So his Intention in the Fertility of a Tortoise, is, not barely to continue that Species, but to accommodate a Number of other Animals with Food convenient for them.

But whence could arise the common Opinion, concerning the Generation of Soles? Namely, that they are produced from a Kind of *Shrimps* or *Prawns*? A French Gentleman being determined to try, put a large Quantity of Prawns, into a Tub about three Feet wide, filled with Sea-water. At the End of twelve or thirteen Days, he saw there eight or ten little Soles, which grew by Degrees. He repeated the Experiment several Times, and always found little Soles. Afterwards he put some Soles and Prawns together, in one Tub, and in another Soles alone. In both the Soles spawned; but there were no little Soles, only in the Tub where the Prawns were.

But how can Prawns be of Use toward producing Soles? Farther Observation cleared up this. When Shrimps or Prawns are just taken out of the Sea, you may discern between their Feet many little Bladders, which are strongly fastened to their Stomach, by a Kind of Glue. If you open these Bladders gently, you see a Sort of Embryo's, which viewed with a Microscope, have all the Appearance of Soles.

Now here lies the Mystery. These are the Eggs or Spawn of Soles, which in Order to hatch, are fastened

to the Shrimps or Prawns : Like many Plants and Animals, which do not grow or receive Nourishment, but upon other Plants and Animals. The Prawns therefore are the Foster-mothers of Soles, during their First Infancy. And this has occasioned many to imagine, they were their real Mothers.

The coming of certain Kinds of Fish in Shoals to certain Coasts, at a certain Time of the Year, is of great Advantage to Mankind. But the Reason of it has been little understood. Yet Observation may clear it up. There is a small Insect common in many Seas, particularly on the Coast of *Normandy*, in June, July, and August. They then cover the whole Surface of the Water as a Scum. And this is the Season when the Herrings come also in such prodigious Quantities. The Fishermen destroy much of these Vermin; yet to these alone their Fisheries are owing. For it is evident the Herrings feed on these, by the Quantities found in all their Stomachs. And doubtless, the very Reason of their coming is to feed upon them. Probably the Case is the same in all other Places, where the Herrings come in the same Plenty.

The numberless Swarms of Herrings, Cod and other Fish, that come forth yearly from their Shelter, under the Ice adjoining to the North Pole, divide themselves into three Bodies. One Part direct their Course Southward, toward the *British* Islands : Another Part Westward, toward *Newfound-land*, and other Places in *North-America* : And the third Part along the Coast of *Norway*, and then thro' the Sound into the *Baltic*.

The Water, tho' quite still before, curls up in Waves wherever they come. They croud together in such Numbers, that they may be taken up by Pail-fulls.

A large Shoal of Herrings; reaches (according to the Fishermens Account) an hundred, or two hundred Fathom deep. They extend also to a considerable Circumference. Were they all to be caught, the greatest Part would be lost. For it would be impossible to get Hands, Tubs, Salt, and other Necessaries to cure them.

them. Several Hundred Ship-loads are sent every Year from *Bergen* alone to foreign Parts: Beside the Quantities that the Peasants at home consume, who make them their daily Provision.

Mackrels come in the same Numbers at certain Times of the Year; and for the same Reason. They are particularly fond of a Sea-plant, the *narrow-leaved, purple Sea-wick*, which abounds on the Coasts of *England*; and is in its greatest Perfection, in the Beginning of Summer: Tho' at sometimes later than other, according to the Severity or Mildness of the Winter.

The chief Occasion of their coming is to feed on this Plant. And those who attend to its growing up, would know when to expect the *Mackrel*, better than those who listen for Thunder. ⁱ

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ⁱ But this is not the sole Occasion of their coming. The real Truth is this. The Sea near the Pole is the native Country of all *Fish of Passage*. The Ice which continually covers that Sea, affords them a safe Retreat. Large, voracious Fish, want a free Air for Perspiration, and cannot pursue the smaller Sort into their Sanctuaries, where they multiply so prodigiously, that at length for Want of Subsistence, they are forced to quit their Retreat. The large Fish wait for them at the Extremity of the Ice. They devour all they can catch, drive them close into the Coasts, while the Birds of Prey pour down upon them from all Quarters. In Consequence of this Persecution their March is always in Columns, which are commonly as thick as they are broad. With regard to the *herrings*, they quit the Ice in the Beginning of the Year. But the prodigious Column which they form, soon divides into two Wings. The Right moves Westward, so as to be near *Iceland*, in the Month of March. The Left bends its Course Easterly, and comes down the North Sea to a certain Latitude, where it divides into two other Wings, the Easternmost of which Coast along *Norway*. Hence it sends off one Division, by the Strait of the *Sound*, into the *Baltic*, another toward the Country of *Holstein*, *Bremer*, &c. and thence into the *Zuiderzee*. The Western Wing, which is the largest, falls directly upon the Isles of *Shetland* and the *Orkneys*. And thither the *Dutch* go to wait their Coming. All that escape these dextrous Fishers, go on toward *Scotland*, and dividing again into two Columns, one passes to the East of that Kingdom, and goes round *England*, detaching numerous Divisions to the Coasts of *Friesland*, *Holland*, *Zeeland*, *Flanders* and *France*, while the other moves to the Westward of *Scotland* and *Ireland*. The Remains of the whole Western Wing, which have escaped the Nets of the Fishers, and the Voracity of other Fish and Fowl, having at Length rallied in the Channel, the Column is

The *Tunnies* come in equal Shoals at certain Seasons, to the Coasts of *Provence* and *Languedoc*. But it is on another Occasion. The Fish called by the *French* the *Emperor*, is the great Enemy of these Fish. He is in Summer so plentiful in those Seas, that they cannot escape him but by flying to the shallow Waters.

The *Pilchards* catched on the Coast of *Bretany*, are still a stronger Proof, of the natural Means that bring Fish in Shoals to certain Places. The People of *Bretany* purchase from *Norway*, the Offals and Entrails of all the large Fish caught there. These they cut in Pieces, and straw in vast Quantities on the Sea along their Coasts. This always brings thither Shoals of *Pilchards*, enough to supply all the maritime Places in the Neighbourhood.

The *Salmon* (bred both in the Sea, and in Rivers) is another Fish, which comes in Shoals at certain Times. But this is on another Occasion. The Female *Salmon* chiefly ejects her Roe at the Mouth of Rivers, in shallow Water. The Male comes presently after, keeps other Fish from devouring it, and casts his Sperm upon the Roe. They are in great Plenty from the Middle of April till the Middle of July; at which Time, also they come in Shoals into the Rivers, partly to refresh themselves in fresh Water, and partly to rub or wash off in the strong Currents, a greenish Vermin, called *Salmon lice*; Insects wisely designed by the Creator, to drive this rich and valuable Fish, into the Hands of Men.

The *Salmon* when they are going up the Rivers out of the Sea, always swim as near the Bottom as they can. And on the Contrary, when they are going down them

formed anew; and then issues into the Ocean: From which (without shewing itself again on the Coasts) it regains, like the Remains of the first Western Wing, which had not travelled so far, the Polar Ice, at the Approach of Winter. And under the Protection of this, the Loss is repaired, which the Species had suffered since they left it.

Thus does the Divine Wisdom supply many Thousands of Men with Food, as well as numberless other Animals: And yet prevent any Decay of that necessary Provision, which is continually consumed and as constantly recruited!

them into the Sea, they always swim near the Surface. The Reason is, in going up, they swim against the Current, which always runs swiftest at the Surface. When they are going down on the Surface, the Current alone is sufficient to carry them.

8. One particular Instance of the Divine Care, is observable in the *Turbot*. Having no Air-bladder, he is not well able to swim, especially in stormy Weather. He must then keep at the Bottom, and stick in the Sand. And for that Reason he is provided, with a Skin or Membrane which draws over his Eyes, to keep the Sand out of them.

In Fishes of the *Whale-kind*, the Tail has a different Position from what it has in all other Fishes. For whereas in these it is erected perpendicular to the Horizon, in them it lies parallel thereto; partly to supply the Use of the hinder Pair of Fins, which these Creatures have not, and partly that they may be able to raise or depress their Body at Pleasure. For it being necessary they should frequently come to the Top of the Water, to take in, or let out the Air, they are provided with an Organ to facilitate their Ascent and Descent as they have Occasion. And as for turning their Bodies in the Water, they perform that as Birds do; by strongly moving one of their Fins, while the other is quiescent.

9. The *Norway Whale* is frequently sixty or seventy Foot long: His Shape pretty much resembles that of a Cod: He has a large Head, and small Eyes in Proportion. On the Top of the Head are two Openings, thro' which he spouts out the Water (which he takes in, as he breathes) like a large Fountain, which makes a violent Noise.

His Skin is smooth and not very thick. The Colour of his Back is dark and marbled. His Belly is white. His Throat is very narrow, in Proportion to his Size. Under his Backbone lies a long Bladder, which he dilates or contracts, as he pleases. He rows himself with his Tail. They copulate after the Manner of Land Animals.

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The Female brings forth but one or two at a Birth at which Time they are nine or ten Foot long. They suck for some Time: When they are tired with Swimming, she carries them between her great Fins. Under the Skin lies the *Blubber* or Fat. Its usual Thickness is about six Inches: But about the under Lip it is found two or three Feet thick. Out of this the Oil is extracted. One Whale ordinarily yields 40 or 50; sometimes 80 or 90 hundred Weight.

The Use of *Blubber* seems to be, partly to poise the Body and make it equiponderant to the Water; partly to keep the Water at a Distance from the Blood, lest it should be chilled by its immediate Contact; and partly to keep the Fish warm, by reflecting the hot Steams of the Body, and so redoubling the Heat.

Under the Fat is the Flesh of a reddish Colour. Their general Food, is certain small Insects, which float upon the Water, in great Heaps, and are no larger than Flies. But they likewise eat various Sorts of small Fish, particularly Herrings, which they drive together in large Shoals, and then swallow vast Quantities at a Time. The Whale commonly goes under the Shoal; then opens his Mouth and sucks in all he can. Sometimes he swallows so many, that he is ready to burst, and sets up an hideous Roar.

But he is far more troubled by a slender Fish about four Feet long, which tears great Pieces of Flesh out of him. The Whale then not only makes a frightful Noise, but often leaps a considerable Height. In these Leaps he sometimes raises himself perpendicular, above the Surface of the Water, and then plunges himself down with such Violence, that if his Head strikes against any of the hidden Rocks that are in the Shallows, he fractures his Skull, and comes instantly floating up dead. So there is no Creature in the World so great or strong as to be exempt from Calamities!

It may not be unacceptable or unprofitable to those who see God even in his lowest Works, to add a short Account of a few more Inhabitants of the Waters.

Flying-Fish are very rarely a Foot long. They have a pretty large, tho' thin and light Head. The Mouth

is generally open ; the Body small, roundish and tapering toward the Tail : Beside the usual Fins, they have under their Necks, three broad and pretty long ones, of a more subtle Structure, nearly as thin as a Fly's Wing, but strengthened with Rows of Bones. On the back Part of their Neck they have also a flying Fin, about six Inches long, quite erect. And lower down the Back, there is another shorter, but broader. These Wings they use to escape the Pursuit, of Creatures too powerful for them. They rise several Feet above the Water, and fly the Length of two or three Musket-shot. Then they drop, because their Wings are dry, which serve them no longer than they are moist.

The *Int-Fish*, as some call it, has a still more extraordinary Way of escaping its Pursuers. " I have lately," says the Author of the Natural History of *Norway*, " procured a dried one, which is two Foot long. The Body is almost round, resembling a small Bag, and is blunt at both Ends. But the Head is the most remarkable Part. It has two large Eyes and a Mouth like a Birds Beak. Above this stand eight Horns, like a Star. Each Horn is octangular, and covered with many small, round Balls, something larger than a Pin's Head. On each Side of the Body there are two skinny Membranes, with which he can cover himself all over. The Fore-part of the Body is quite filled with a black Fluid. When it is pursued, it discharges this which colours the Water all around, and renders it invisible. This is a wonderful Gift of Nature, for the Preservation of an Animal, otherwise utterly helpless.

The *Arborescent Star-fish* is another of the Curiosities of Nature. It is upwards of a Foot in Diameter, having its Mouth in the Middle. The Figure of the Trunk, is pentangular, and from the five Angles arise as many Branches, which subdivide into several others, and those again into others that are less, till the last are scarce thicker than Horse-hairs, and in Number above a thousand. In Swimming he spreads all these Branches like a Net ; and when he perceives any Prey within them, draws

draws them in again, and so takes it with all the Dexterity of a Fisherman.

Full as surprizing a Creature is the *Torpedo*, a flat Fish, much like a Thorn-back. It is common on the Coasts of *Provence*, and is eaten without any ill Effect. But upon touching it with the Finger, the Person commonly (tho' not always) feels an unusual, painful Numbness, which suddenly seizes him up to the Elbow, and sometimes up to the Shoulder. It resembles, but far exceeds, the Pain felt by striking the Elbow violently against an hard Body. But it lasts only a few Moments, and gradually wears away. If a Man touch it even with a Stick, he feels a little of it. If he presses his Hand strongly against it, the Numbness is the less. But it is so uneasy as to oblige him, very speedily to let it go. Many have attempted to account for this; but should we not rather, honestly own our Ignorance?

The *Sea-nettle*, so called, is another strange Production of Nature, common, I suppose, in all the Northern Seas. It generally swims on the Top of the Water, and is throughout soft, smooth and transparent. It appears to be a Lump of Slime or Jelly. But it co-heres firmly together, being marked in the Middle with a Cross somewhat like a Flower-de-luce.

These Creatures are Blue, White or Red, and some of them have many Branches underneath. These are usually something larger than the common Sort, and are of a dark Red. They all abound with a corrosive Poison, which if it drop on any Part of the Body will cause a Smart and an Inflammation, much like that produced by Nettles. Hence it has its Name. However it is no Vegetable, but is evidently a living Creature. For it has Sensation: It grows, moves to and fro, contracts and extends itself. It often picks up and devours small Fish, and is itself devoured by others.

The Care of the Creator is observable, even in so inconsiderable a Creature as a *Limpet*, a small Shell-fish, which so fastens itself to the Rock, that scarce any Thing can unloose its hold.

The Fact has long been known. But the Manner of its fastning itself, was not understood till very lately.

Its Shell approaches to the Figure of a Cone ; the Base of which is occupied by a large Muscle, which alone has nearly as much Flesh in it, as the whole Body of the Fish: This is not covered by the Shell, but serves the Creature equally to move forward or to fix itself to the Rock. When it is in a State of Rest, which is the common Case, it applies this Muscle every Way round to the Surface of some Stone, and thereby holds itself fixt to it so firmly, that it is impossible to take it off with the Hands. Those who would remove them are obliged to make Use of a Knife for that Purpose. And even then it is not easy : For on whatsoever Side the Blade of the Knife attempts to enter, the Fish immediately fixes its Muscle with double Force to the Stone.

The true Cause of this Adhesion is a viscus Juice, a Kind of Glue, thrown out by this Muscle, which tho' it is not perceptible to the Eye, yet is easily perceived by the Touch. For if immediately after the removing a Limpet from the Stone, the Finger be applied to the Place, it is fastened very strongly to it, by Means of the Glue left there. But if any Wet have come upon the Stone, since the Fish has been removed, no Viscosity can be perceived on it, the whole Substance of the Glue being immediately dissolved. This Consideration may lead us to observe the great Care of Nature over all her Works. How eminently is it manifested in this little Fish ? It was absolutely necessary for its Preservation, that it should have a Power of fixing itself to the Stone, or it would have been washed away by every Wave. And this Power is given it, by Means of that Glue which fixes it so firmly. But when it is fixt, how shall it be loosed ? This is equally Necessary. For if there be not some Power in the Animal itself, to dissolve this Glue, it must needs perish for want of Food, when once fixt to a barren Spot. Water is the proper Dissolvent of this Glue. But it cannot be the external Water. This is kept at a Distance, by the close Adhesion of the outer Rim of the great circular Muscle. And 'tis needful it should : Else it would always dissolve the Glue, as soon as it was discharged. But the under Surface of the Body of the Animal is covered all over with small Tubercles, most of which

which contain Water. When therefore it would move, it has only to discharge a small Quantity of this Water, and the Cement immediately dissolves and sets it at Liberty. The other Tubercles doubtless contain the viscous Matter. So that when the Animal would fix itself, it needs only to squeeze one set of its Tubercles, and when it would loose itself, the other.

One can hardly tell whether to rank the *River-horse* among Land or Water-Animals. He sleeps on Land, but passes all the rest of his Time under Water. But in one Respect he is different from all other Creatures, that live partly on Land and partly in the Water. All other Sorts of amphibious Animals have the Faculty of swimming; but this has not. He has to feed under Water, yet is the most unwieldy of all Creatures, and cannot swim at all. He comes out of the Water in an Evening to sleep: And when he goes in again, he walks very deliberately in overhead, and pursues his Course along the Bottom, as easy and unconcerned as if it were in the open Air. The Rivers he most frequents are very deep, and where they are clear, this affords an astonishing Sight.

The *River-horse* is as tall as the tallest Horse; its Body much larger, and his Legs thicker and shorter. His Skin is quite naked, without Hair, and is black and very coarse. The Head is exceeding large, and his Mouth (which he has a Way of opening very frequently, and of tossing up his Head at the same Time) is the most terrible that can be imagined. His Teeth are blunt, but very thick and long, and are harder than any other Animal Substance. The Tail is short; and the Feet are not solid, like those of an Horse, but divided each into four Toes.

An Animal of this Size and Make, must be one of the strongest in the World. It therefore required from Nature no Swiftnes, either to avoid Pursuit, or to overtake its Prey, as it was designed to feed on Vegetables. The Manner of its feeding is this. When he walks into a River, he seldom looks about till he is near the Middle. Here he seeks for the larger Water-herbs, particularly for the root of a large Water-lilly. People from a Boat

on

on the Surface frequently see this. He roots up these with his Nose, like an Hog, and his Mouth and Throat being very wide, swallows them in vast Morfels half chewed.

But he has frequently Occasion to breathe; in Order to which, when feeding at his Ease, his Custom is, every ten Minutes, to rise to the Surface of the Water. This he does, by a Spring from the Bottom, made with all his Feet at once. Having taken a little fresh Air, and looked about him, he drops to the Bottom again.

Another amphibious Animal, no less unwieldy than the River-horse, is the *Tortoise*. In several Countries they are small; but in the *East-Indies* they are five or six Feet long. Having small and weak Feet, they are exceeding slow in their Motions. They have neither Tongue, nor Teeth, nor any offensive Weapon. How then can they take, how can they chew, or in any Degree, comminute their Food? This is well provided for: They break not only Shells, but sometimes even Stones with their Lips: Which by their excessive Hardness effectually supply the Want of Teeth. But how can they defend themselves? Abundant Provision is made for this also. Their Shells more than cover the whole Body, and are of so firm a Texture, that a loaded Waggon may go over them, without any Injury either to the Shell or the Creature within it.

g. Upon the whole, how natural are the Reflections, which a late Writer makes on the Inhabitants of the Waters?

What an Abundance of Fish do the Waters produce? In these I seem to discern Nothing but a Head and a Tail. They have neither Feet nor Hands. Nor have they any Neck: So that their Head cannot be turned at all, any otherwise than by turning the whole Body. Were I to consider their Figure only, I should think they were destitute of all that was necessary for the Preservation of their Life. But with these few outward Organs they are more nimble and dextrous, than if they had several Hands and Feet. And by the Use they make of their Tails and Fins, they are carried along like Arrows.

But as almost all Fishes prey upon each other, and cannot sustain their own Lives, any otherwise than by continually destroying those of their own Species, How can the Inhabitants of the Waters subsist? How can many Species escape utter Destruction? God has guarded against this, by multiplying them in so prodigious a Manner. More than three hundred thousand Eggs have been counted, in the Roe of a single Salmon. By this Means, let them be destroyed ever so fast, still their Increase is equal to their Consumption.

But who can explain, how the Inhabitants of the Sea enjoy their perfect Health, in the midst of Water so loaded with Salt? And by what Art is it, that they preserve even there, a Flesh that has not the least Taste of it?

Why do those which are fittest for the Use of Man, come and offer themselves on our Coasts? While so many that would be useless, if not pernicious, affect Remoteness from us.

Why do several of them, in their stated Seasons, run up into our Rivers, and communicate the Advantages of the Sea, to such Countries as are far distant from it? What Hand conducts them with so much Care and Goodness, but thine, O thou Preserver of Men?

CHAP.

C H A P.

Of Reptiles.

1. *Of their Motion :*2. *Of Serpents :*3. *Of their Brain,**Stomach, Generation :*4. *Venom :*5. *Of some particular Sorts
of Reptiles.*

1 **N**OT far removed from Fishes are *Reptiles*, so named from their creeping, or advancing on the Belly. Many Species of them have Legs and Feet; but very small in Proportion to the Body. There is a World of Contrivance in their Motion. The whole Body of the Earth-worm, for Instance, is a Chain of annular Muscles, or rather, one continued Spiral Muscle, the orbicular Fibres whereof being contracted, make each Ring narrower and longer, by which Means it is enabled, like the Worm of an Augre, to bore its Passage into the Earth. Its creeping may be explained by a Wire wound on a Cylinder. If this is taken off, and one End extended and held fast, it will bring the other near it. So the Worm having shot out its Body, which is Spiral, takes hold by its small Feet, and so brings on the hinder Part. Its Feet are placed in a Four-fold Row, the whole Length of the Worm. With these, as so many Hooks, it fastens to the Earth or whatever it creeps over, sometimes this, sometimes that Part of the Body, and stretches out or draws after it another.

2. The most eminent Species of *Reptiles* are *Serpents*, which we may therefore particularly consider. Their Bodies are of a very peculiar Make, having a Compagae of Bones articulated together. Here Part of the Body is applied to the Ground, and the other Part shot forward, which being applied to the Ground in

its Turn, brings the other after it. The Spine of their Back variously writhed, helps their leaping, (as the Joints of the Feet in other Animals.) They make their Leaps by Means of the Muscles that extend the Folds thereof.

3. Their *Brain* little differs from that of Fishes: But their *Stomach*, very much. It is like a loose Gut, which runs along, from the Jaws quite to the Tail. They have likewise solid Ribs and Vertebrae, at small Distances, from the Neck to the End of the Tail. Hereby they are enabled, to raise themselves up, to support, to writhe themselves into Rings, to spring forward, and to suck or swallow any Thing, with surprizing Force. And their whole Flesh is of so close and firm a Texture, that they will live for some Time, even after they are cut in Pieces.

There is a great deal of Geometrical Nicety in the sinuous Motion of Serpents. For the assisting herein, the annular Scales under their Body are very remarkable, lying cross the Belly, contrary to those in the Back and the rest of the Body. Also the Edges of the foremost Scales, lie over the Edges of the following Scales from Head to Tail, So that when each Scale is drawn back, or set a little upright by its Muscle, the outer Edge of it is raised a little from the Body, to lay hold on the Earth, and so promote the Serpent's Motion. But there is another admirable Piece of Mechanism, that every Scale has a distinct Muscle, one End of which is fixt to the Middle of its Scale, the other to the upper Edge of the next Scale. There is Nothing peculiar in the Generation of Serpents, most of which are oviparous.

4. *Vipers* and many other Serpents have small Bags near the Root of their Teeth, which contain the Poison. When they bite, this is squeezed out, by the Compression of those Bags. If they are taken out of a Viper, the Liquid they contain mixt with the Blood of an Animal, causes Death. But if taken in by the Mouth, it does no Harm, losing its Efficacy by mixing with other Liquids.

A Viper

A Viper has the biggest and flattest Head of all the Serpent Kind. It is usually half an Ell long and an Inch thick, with a Snout not unlike that of an Hog. It has sixteen small Teeth in one Row; beside two large, sharp, hooked, hollow, transparent Teeth, placed at each Side of the lower Jaw. These convey the Poison into the Wound, thro' a long Slit. They are flexible, and then only raised, when the Viper is going to bite. The Roots of them are incompast with a little Bladder, containing a large Drop of a yellow, insipid Juice. The Slit is a little below the Point of the Teeth, which are not hollow to the Top. Hence arise all those dreadful Symptoms, which frequently end in Death. But they are all prevented or removed, by rubbing Oil upon the Wound.

Vipers creep but slowly, and never leap or bite, unless provoked. They are of a yellowish Colour, speckled with longish, brown Spots. The Belly is of the Colour of well-polished Steel. Other Serpents lay Eggs; the Female Viper only brings forth her Young alive, wrapt up in Skins, which break on the third Day, and set them at Liberty.

The Poison of a *Rattle-snake* is equally fatal and more swift in its Operation. For it frequently kills within an Hour. The Snake is from ten to fifteen Feet long. But whenever it moves in order to bite, the Tail begins to rattle: And that considerably loud: So that a Man if he has Presence of Mind, may easily get out of his Way. When he bites an Hare, he is observed to lick her all over before he takes her into his Mouth: Probably, that having moistened and smoothed her Skin, he may the more easily swallow her.

It is very remarkable, that he frequently stays under a Tree on which a Bird or Squirrel is hopping about, with his Mouth wide open. And the Event constantly is, the Creature in a while drops into it. Sir *Hans Sloane* thinks, he has wounded it first: And that he then waits under the Tree, till the Poison works and the Animal drops down into the Mouth of its Executioner.

But this is not the Case, as plainly appears, from what many have been Witnesses of. A Swallow, pursuing his Prey in the Air, if he casts his Eye on a Snake beneath him, waiting with his Mouth wide open, alters his Course, and flutters over him in the utmost Consternation, till sinking gradually lower and lower, he at last drops into his Mouth.

To the same Purpose is the famous Experiment of Dr. *Sprenger*, mentioned in the *Hamburgh Magazine*. He let loose a Mouse on the Ground, at a little Distance from a common Snake. It made a few Turns, and squeaked a little, and then ran directly, into the Mouth of the Snake, which all the while lay still, and without Motion.

5. It is a wonderful Provision which is made for those Snakes, who are Inhabitants of the Waters.
A Water-

1 The *Rattle-Snake* being less nimble than others, would find Difficulty in getting its Prey, were it not for the singular Provision made; by the Rattle in his Tail. When he sees a Squirrel or Bird on a Tree, he gets to the Bottom, and shakes this Instrument. The Creature looking down, sees the terrible Eye of the Snake bent full upon it. It trembles, and never attempts to escape, but keeps its Eye upon the Destroyer, till tired with hopping from Bough to Bough, it falls down and is devoured. Indeed the same Power is in the Viper. The Field-Mice, and other Animals, which are its natural Food, if they have once seen his Eyes, never escape, but either stand still, or run into its Mouth.

But Vipers in general will not eat, after they are under Confinement. The Viper-catchers throw them together into great Bins, where they live many Months, tho' they eat Nothing. It is only a Female Viper, when big with young, that will eat during its Confinement. If a Mouse be thrown into the Bin, at the Bottom of which 40 or 50 Vipers are crawling, among which One is with Young, she alone will meddle with it, and she not immediately. The rest pass it by, without any Regard, tho' it be their natural Food. But the Female, after she has done this several Times, will at Length begin to Eye it. Yet she passes by it again, but soon after stops short, and holding her Head facing that of the Mouse, seems ready to dart at it, which however she never does, but opens her Mouth, and brandishes her Tongue. Her Eyes having now met those of the Mouse, she never loses Sight of it more; but they face one another, and the Viper advances with her open Mouth, nearer and nearer, till without making any Leap, she takes in the Head, and afterward the whole Body.

A *Water-snake* has no Air-bladder like Fishes: But to make amends for this Want, it has a large membranous Air-bag on its Back, which it empties or fills with Air at Pleasure, by an Aperture which it can shut so close, that the least Globule of Water cannot enter. By this Means it can enlarge or lessen the Bulk of its Body, and inhabit any Depth of Water.

As for the *Serpent of the Waters*, of which an Account is gravely given, by the Writer of the Natural History of *Norway*, which he talks of, as being five or 600 Yards long, and as rearing his Head higher than the Main-mast of a Man of War, I presume it is very nearly related, to the *Craken* of the same Author: A Sea-monster, to which a Whale is but a Shrimp, larger than twenty Men of War put together. And this our Writers of Magazines and Reviews, swallow without any Difficulty! Is it from the just Judgment of God, that Men who do not believe the Bible, will believe any Thing?

The King of all Reptiles which are known with any Certainty, is the *Crocodile*. The *American Crocodile* or *Alligator*, is only fifteen or sixteen Feet long. But those bred in *Afric* or the *East-Indies*, are said to be between five and twenty and thirty. It may well be said of him (which cannot of the *Whale*) that *his Scales are his Pride*: For on his Back, as well as his Head, they are impenetrable as Steel. Contrary to almost all other Creatures, he moves only the Upper Jaw. No Creature dares withstand him. *He is the King of all the Children of Pride*. And as every Female *Crocodile* lays some hundreds of Eggs at once, they would utterly dispeople the Waters, were it not that the Male devours all he can find of them. And so diligent is he in his Search, that scarce one out of an Hundred escapes him. It is another Instance of Divine Mercy, that he cannot bite under Water. By this Circumstance, Creatures that are able to dive, generally escape his ravenous Jaws.

The *Chameleon* (as well as the *Alligator*) is of the Lizard Kind. Some in *Egypt* are twelve Inches long; but the *Arabian* seldom exceeds six. He has four Feet

Feet and a long, flat Tail, whereby he hangs on Trees, as well as by his Feet. His Snout is long, his Back sharp, and grained, like Shagreen. He has no Ears, neither does he make or receive any Sound. The Tongue is half the Length of the Animal, round to the Tip, which is flat and hollow, somewhat like an Elephant's Trunk. And this he darts out, and draws back with surprizing Swiftneſs.

The great Uſe of this is, to catch Flies, (which are its proper Food, not the Air, as is vulgarly thought) by darting it out upon them. Its Colour is not always the ſame. One at *Paris*, when it was in the Shade, and at Reſt, was of a bluifh Grey. In the Sunſhine this changed to a darker Grey, and its leſs illumined Parts to various Colours. When handled or ſtirred, it appeared ſpeckled with dark Spots bordering upon green. If it was wrapt up a few Minutes in a Linen Cloth, it was ſometimes taken out whitifh. But it did not take the Colour of any other Cloth or Subſtance that incloſed it. So that its aſſuming all the Colours it comes near, is a groundleſs Imagination.

The Chameleon at *London* was of ſeveral Colours, like a mottled Coat. The moſt diſcernible were, a Green, a ſandy Yellow, and a liver Colour. When ſtirred or warmed it was ſuddenly full of black Spots, as big as a large Pin's Head. But when it was quiet, they gradually diſappeared.

There are four Species of Chameleons. 1. The *Arabian* about the Size of the green Lizard. This is of a whitifh Colour, variegated with reddiſh and yellowiſh Spots. 2. The *Egyptian*, which is of a middle Hue, between a whitifh and a fair Green. 3. The *Mexican*. and 4. A Kind which has been frequently ſhewn in *Europe*, and differs from all the reſt. His Head is large; but he alters his Body at Pleaſure, inflating it more or leſs: And not only his Body, but his Legs and Tail. This is peculiar to him. The Body thus puſſed up, will remain ſo two Hours. But it is inſenſibly ſinking all the Time. It can continue a long Time in either of theſe States; but is generally uninflated. It then looks miſerably lank and lean: Its Backbone may

may be seen perfectly ; its Ribs counted, and even the Tendons of the Feet distinctly seen thro' the Skin.

Its Mouth is furnished with continued, denticulated Bones : But it does not appear what Use they are of, since it preys on Flies and swallows them whole, unless for holding a Stick in its Mouth cross-ways : Which, according to *Ælian*, he frequently does, to prevent being swallowed by Serpents.

The *Structure* and *Motion* of his Eyes are surprizing. They appear to be large Spheres, of which one Half stands out of the Head, and is covered with a thick Skin, perforated with a small Hole at Top. Thro' this is seen a very vivid and bright Pupil, surrounded with a yellow Iris. This Hole is a longitudinal Slit, which he opens more or less at Pleasure. The *Motion* of his Eyes is not less singular. It can turn them, so as to see either forward, backward, or on either Side, without moving the Head at all, which is fixt to the Shoulders. And he can give one Eye all these Motions, while the other is perfectly still. Each Foot has five Toes, all of one Side, two behind and three before : He moves very slowly on the Ground, but on Trees more easily. Its Tail is then in Safety, as it twists it round the Branches, when in any Danger of falling. ^m

Another uncommon Creature of the Lizard Kind is a *Salamander*. This is supposed to live in Fire : but without any Ground. It is indeed generally found in the Chinks of Glass houses, or near Furnaces, where the Heat is so great, that no other Animal could endure it, without being destroyed in a few Minutes. But some Years ago, the Trial was made by several Gentlemen, whether it could really live in Fire. Some
Charcoal

^m But how can so slow a Creature, catch the most nimble Sort of Insects ? What Nature has denied it in Agility, is abundantly supplied by other Means. Its slow, and easy Motion renders it but little suspected at a Distance. And when it comes within a proper Space of its Object, it stretches out its Tail, poises its Body, and fixes itself, so as seldom to meet with a Disappointment. When all is ready, it uncoils its long, slender Tongue, and darts it so swift as scarce ever to miss its Prey.

Charcoal was kindled, and the Animal laid upon the burning Coals. Immediately it emitted a blackish Liquor, which entirely quenched them. They lighted more Coals, and laid it upon them. It quenched them a second Time in the same Manner. But being presently lain on a fresh Fire, it was in a short Time burnt to Ashes.

That *Earth-worms* feed upon Earth, will be put beyond Dispute, if any one is at the Pains to examine, the little curled Heaps of Dung, which are ejected out of their Holes. But it is in all Probability, not pure Earth, but such as is made of Leaves, Roots, and Plants, when gradually rotted and mouldered away. And what makes this the more probable, is that they are observed to drag the Leaves of Trees into their Holes.

One more Reptile we may examine a little more minutely, in which the Wisdom of God is not a little displayed. It is a common *Leech*. When this is at Rest, its upper Lip forms a regular Semicircle. When he moves, this Semicircle becomes two oblique Lines, the Junction of which makes an Angle, which he applies to whatever he would fix himself to. The two Lips then make a Sort of Hollow. Both these and its Mouth are made of so supple Fibres, that they take the Figure of the Part they are applied to, and fix perfectly close to it.

The Wounds it makes are not Punctures, but three Cuts, made like three Rays, which uniting in a Center make equal Angles with each other. They appear as if made by a fine Lancet. They are indeed made by three Rows of fine and sharp Teeth, which the Microscope shews to be placed along the Middle of a strong Muscle. When the Mouth has seized on any Part, the Muscle exerts its Action, and strikes in all the Teeth at once.

Between the Mouth and the Stomach, there is a small Space, in which are two different Arrangements of Fibres. The one Set are flat and plain, the others are circular. The former contracting in Length, enlarge the Capacity of the Throat; and the Circular ones determine the Blood toward the Stomach, by contracting

contracting it, when the Blood is received. Hence it passes into a Kind of membranous Sack, which serves the Animal both for Stomach and Intestines. This takes up the greatest Part of its Body. On each Side of this long Canal, there is a Number of little Bags. These being filled with Blood, swell out the Body of the Animal to a great Size. Here it remains for many Months, and serves the Creature for Nourishment. If any Thing is excreted, it can be only by insensible Perspiration, since the Creature has no Anus, nor any Aperture which can supply the Place of one.

C H A P. V.

Of Insects.

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| 1. Of their Shape, and Make: | 10. Of the Death-watch: |
| 2. Of their Eyes: | 11. Of the Eggs of Flies: |
| 3. Of their Heart, Respiration: | 12. Of Gnats: |
| 4. Of their Generation; particularly of the Silkworm and Silk-spider: | 13. Of the Cicadula: |
| 5. Of the common Spider: | 14. Of the Drone-fly: |
| 6. Of the Tarantula: | 15. Of the Fire-fly: |
| 7. Of Microscopic Animals: | 16. Of the Ephemeron: |
| 8. Of the Flea: | 17. Of Butterflies: |
| 9. Of the Louse: | 18. Of Caterpillars: |
| | 19. Of the Transformations of Insects: |
| | 20. Of Ants: |
| | 21. Of the Ant-Eater: |
| | 22. Of Bees. |

11. **T**HERE remains only the lowest Order of Animals, usually termed *Insects*, because they have an Incision, as it were, which in a Manner cuts them into two Parts. Of these I would speak the more largely, because generally they are little known. Rather

Rather they are despised and purposely passed over, as unworthy of our Consideration. And yet it is certain, the Wisdom of the Great Creator, does most conspicuously shine in them.

As to the *Shape* of their Bodies, tho' it be somewhat different from that of Birds, being for the most Part not so sharp before, to cut and make Way thro' the Air, yet it is better adapted to their Manner of Life. For considering they have little Need of long Flights, and that the Strength and Activity of their Wings, far surpass the Resistance they meet with from the Air, there was no Occasion for their Bodies to be so sharpened. But the Nature of their Food, the Manner of gathering it, and the great Necessity they had of accurate Vision, and large Eyes in order thereto, required the Largeness of the Head, and its Amplitude before the rest of the Body is all well-made, and nicely poised for their Flight and other Occasions.

The Make of their Bodies is no less admirable: Not built throughout with Bones, covered over with Flesh, and then with Skin, as in most other Animals: But cloathed with a curious Mail of a middle Nature, serving both as a Skin and Bone too. As it were on Purpose to shew, that the Great Contriver of Nature is not bound up to one Way only.

How admirably are the Legs and Wings fitted for their intended Service? Not to overload the Body, nor to retard it, but give it the most proper and convenient Motion. What for Example, can be better contrived for this Service than the Wings? Distended and strengthened by the finest Bones, and these covered with the finest and lightest Membranes; some of them adorned with beautiful Feathers: ^a And many of them provided with the finest Articulations, and Foldings, in order to be laid up in their Cases, when they do not use them; and yet always ready, to be extended for Flight.

2. The

^a It is easily seen, by the Microscope, that the elegant Colours of Moths and Butterflies, are owing to neat and well-made Feathers, set in Rows with great Curiosity and Exactness.

2. The Structure of the *Eye* is in all Creatures an admirable Piece of Mechanism. But this is peculiarly observable in that of an Insect. Its Hardness is an excellent Guard, against external Injuries. And its outer Coat is all over beset with curious, transparent Inlets, enabling it to see every Way, without any Loss of Time, or Trouble to move the Eyes.

And their *Feelers*, besides their Use in cleaning the Eyes, are a good Guard to them in their Walk or Flight, enabling them by the Sense of Feeling to discover Annoyances, which by their Nearnels might escape the Sight.

The Eye of a Fly is in Truth an Assemblage of Multitudes, often many Thousands of small Eyes. Nature has given each Fly two large *reticular* Eyes (that is, covered with a Kind of Net-work.) And as each contains such a Multitude of smaller Eyes, one would imagine, this might suffice. Yet some Flies have four reticular Eyes; the two smaller are placed as usual, the two larger are behind the other, on the upper Part of the Head.

In different Species the reticular Eyes are of different Colours. Some are brown, some yellow, green, red, and this in all the different Shades of those Colours. And some have the Gloss of Metals highly polished.

But beside these, many Species of Flies have a Sort of Eyes, which are not reticular, but of a perfectly smooth and even Surface, and far smaller than the reticular. Three of these are on the Back of the Head of vast Numbers, which are triangularly placed. Some have more, and some have less than Three. Gnats have none of them. Their Heads are in a Manner covered with their reticular Eyes, so as to leave no Room or Occasion for *smooth* ones.

Nor are these smooth Eyes peculiar to Flies. Other Insects also have them: The Grass-hopper in particular has Two, which are placed near the Nose.

3. The Species of Insects are almost innumerable. All of these some suppose to have no *Heart*, as they have no sensible Heat, none that can be perceived either by the Touch, or by any other Experiment.

But this is a Mistake. Many indeed have not such an Heart as other Animals have : But all have something analogous to it, something that answers the same Purpose.

Some likewise have thought, That Insects have no *Respiration*. But later Experiments shew, that there is no Species of them which has not *Lungs*, and those larger in Proportion than other Animals. In most of them they lie on, or near the Surface of the Body. And hence it is, that if Flies are besmeared with Oil, or any other unctuous Matter, they die in a short Time, their Respiration being stopt, so that they are properly suffocated.

4. Some also have imagined, That Insects were generated out of mere Putrefaction, because they observed Worms come out of putrefied Flesh, which afterward turned to Flies. But it is certain, if putrefying Flesh be shut up close, no Worms are ever generated from it. Hence we learn, that Flies lay their Eggs in Flesh, which hatch when it putrefies : So that the Animal just comes to Life, when its Food is ready for it. All Insects lay their Eggs, where there is Heat enough to hatch them, and proper Food as soon as they are hatched. Those whose Food is in the Water, lay their Eggs in the Water : Those to whom Flesh is a proper Food, in Flesh. Those to whom the Fruits or Leaves of Vegetables are Food, are deposited on the proper Fruits or Leaves. And constantly the same Kind is found on the same Fruit or Plant. Those that require more Warmth are lodged by the Parent, in or near the Body of some Animal. And as for those to whom none of these Methods are proper, the Parents make them Nests by Perforations in the Earth, in Wood, in Combs : Carrying in and sealing up Provisions, that serve both to produce the Young, and to feed them when produced.

The Eggs of all Insects become Worms, commonly called *Nympha*. They are next changed into *Aureta*, so called, inclosed in a Case : And these dying, a Fly or Butterfly succeeds.

To

To trace these wonderful Changes a little, in one Kind of Insect. A *Silk-Worm*, from a small Egg, becomes a Worm of the Caterpillar Kind, and feeds on Mulberry-leaves, till it comes to Maturity. Then it winds itself up into a silken Case, about the Size and Shape of a Pigeon's Egg, and is metamorphosed into an *Aurich*, in which State it has no Motion or Sign of Life: Till at Length it awakes, breaks thro' its silken Sepulcher, and appears a Butterfly.

As soon as the Silk-worm has Strength, he makes his Webb, a slight Tissue, which is the Ground of his admirable Work. This is his first Day's Employ. On the second, he covers himself almost over with Silk. The third, he is quite hid. The following Days he employs in thickening his Ball, always working from one single End so fine a Thread, that those who have examined it, affirm it would reach six Miles.

The *Silk-Spider* makes a Thread, every whit as strong, glossy and beautiful as the Silk-worm. It spins from seven Nipples. These, as so many wire-drawing Irons, draw out a viscous Liquor, which gradually dries in the Air, and becomes Silk.*

Each of these Nipples contains many smaller Nipples, invisible to the naked Eye; thro' the several Perforations whereof, numberless finer Threads are drawn. Before the Spiders begin to spin, they apply more or fewer of the large Nipples to the Body whence the Webb is begun. And as they apply them more or less strongly, more or fewer of the small Nipples come to touch: And accordingly the whole Thread will be compounded of more or fewer single Threads. One compound Thread frequently consists of fifteen or sixteen single ones.

Their Threads are of two Kinds: One serves only for the Webb with which they catch Flies. The other is much thicker and stronger, in which they

Q 2

wrap

* All boneless Insects are Hermaphrodites, as are Snails, Leeches, and many Sorts of Worms. But such Worms as become Flies are not, being indeed of no Sex.

wrap up their Eggs, in order to shelter them from the Cold, as well as from devouring Insects. These Threads they wind loosely round, resembling the Balls of Silk-worms that have been loosened for the Distaff.

The Balls are Grey at first, but turn blackish, when long exposed to the Air. From these Balls a Silk is made, nothing inferior to the common Silk. It takes all Kinds of Dyes, and may be made into all Kinds of Stuffs. Only there is a Difficulty in keeping the Spiders: for they are so extremely quarrellsome, that if an hundred of them be put together, in a few Hours scarce twenty will be left alive.

5. Amazing Wisdom is displayed in the Make of the *Common-Spider*. She has six Teats, each furnished with innumerable Holes. The Tip of each Teat is divided into numberless little Prominences, which serve to keep the Threads apart at their first Exit, till they are hardened by the Air. In every Teat, Threads may come out at above a thousand Holes. But they are formed at a considerable Distance, each of them having a little Sheath, in which it is brought to the Hole. In the Belly are two little soft Bodies, which are the first source of the Silk. In Shape and Transparency they resemble Glass Beads, and the Tip of each goes winding toward the Teat. From the Root of each Bead proceeds another Branch much thicker, which also winds toward the same Part. In these Beads and their Branches is contained the Matter of which the Silk is formed, the Body of the Bead being a Kind of Reservoir; the two Branches, Canals proceeding from it.

It was before observed, that the Tip of each Teat may give Passage to above a thousand Threads. And yet the Size of the Teat in the largest Spider, does not exceed a small Pin's Head. But the smallest Spiders no sooner quit their Eggs, than they begin to spin. Indeed their Threads can scarce be perceived, but the Web formed thereof is as thick and close as any. And no wonder, as 4 or 500 little Spiders often concur in the same Work. How minute are their Teats! When perhaps

perhaps the whole Spider is less than the Teat of its Parent. Each Parent lays 4 or 500 Eggs, all wrapt up in a Bag. And as soon as the young Ones have broken thro' the Bag they begin to spin.

And even this is not the utmost which Nature does. There are some Kinds of Spiders so small, as not to be discerned without a Microscope. And yet there are Webs found under them! What must be the Fineness of these Threads? To one of these the finest Hair is as a Cart-Rope.

There are several Species of Spiders that fly: and that to a surprizing Height. "The last October, says an eminent Writer, I took Notice that the Air was very full of Webs. I forthwith mounted to the Top of the highest Steeple on the Minster [in York] and could thence discern them yet exceeding high above me. Some of the Spiders that fell upon the Pinnacles I took, and found them to be of a Kind, which seldom or never enter Houses, and can't be supposed to have taken their Flight from the Steeple," P

Q 3

6. A

P There are divers Animals, as well as Spiders, that have some Way of Conveyance, utterly unknown to us. Thus the Animals on the standing Waters, so numerous as often to discolour them, and tinge them red, yellow, or green. That these have some Way of Conveyance is certain, because not only most stagnating Waters are stocked with them, yea, not only new Pits and Ponds, but even Holes and Gutters on the Top of Houses, Churches and Steeples. That they have not Legs for travelling so far, is manifest: It is therefore probable, either that they dart out Webs, and can make themselves Buoyant, and lighter than the Air: Or that their Bodies are naturally lighter than Air, and so they can swim from Place to Place. It is highly probable, the Eggs of such as are oviparous, may be light enough to float therein.

To trace this Matter farther: Every one must have observed Threads floating in the Air: But few consider what End they serve. They are the Works of Spiders. Their usual Method is, to let down a Thread, and then draw it after them. But in the midst of this Work they sometimes desist; and turning their Tail according to the Wind, emit a Thread with as great Violence, as a Jet of Water discharged from a Cock. Thus they continue darting it out, which the Wind carries forward, till it is many Yards long. Soon after, the Spider throws herself off from her Web, and trusting herself to the Air, with this long Tail, will ascend swift, and to a great Height.

6. A *Tarantula* is a Kind of Spider, chiefly found near the City of *Tarentum* in *Apulia*. It is about the Size of an Acorn and has eight Eyes and eight Feet. Its Skin is hairy: From its Mouth rise two Trunks, a little crooked and exceeding sharp. Thro' these it conveys it Poison: They seem likewise to be a Kind of moveable Nostrils; being in continual Motion, especially when it is seeking its Food. It is found in other Parts of *Italy*, but is dangerous only in *Apulia*. And there it does little Hurt in the Mountains (which are cooler) but chiefly on the Plains. Indeed it is not venomous, but in the Heat of Summer, particularly in the Dog-Days. It is then so enraged, as to fly upon any that come within it Reach. The

with it. These Lines, which the Spiders attach to them (tho' unobserved) make these Air-threads, that waft them along the Air, and enable them to pray on many Insects, which they could not reach by any other Means.

All Spiders that spin, young as well as old, cast out these Threads, and sail thereby in the Air. And the Threads themselves shew the Use thereof, being usually hung with the Fragments of devoured Animals.

When the Threads are newly Spun, they are always single, and are generally seen ascending higher and higher. But when they are seen coming down, they are sometimes composed of three or four, and either without any Spider or with several. 'Tis plain this happens from the Threads meeting and intangling in the Air, which of Course brings them down.

It is common to see a Spider mount to the topmost Branch of a Bush, and from thence dart out several Threads one after another, trying, as it were how she likes them. When she has darted one several Yards, she will of a sudden draw it up again, and wind it into a Link with her Fore-feet, but more frequently break it off and let it go. A Spider will sometimes dart out and break off many Threads, before it spins one that it will trust to. But at Length she spins one to her liking, and commits herself to the Air upon it.

The Business of Feeding is not all the Use of these Threads: but they evidently sport and entertain themselves by Means of them, floating to and fro in the Air, and changing their Height at Pleasure.

These Air-threads are not only found in Autumn, but even in the Depth of Winter. The serene Days at Christmas bring out many: But they are only short and slender, being the Work of young Spiders, hatched in Autumn, and are thrown out, as it seems only in Sport. The thicker ones of Autumn are the only ones intended to support the old Spiders, when there is Plenty of small Flies in the Air, which make it worth their while to sail among them.

The Bite causes a Pain, like that by the stinging of a Bee. In a few Hours the Patient feels a Numbness, and the Part is marked with a small livid Circle, which soon rises into a painful Tumour. A little after, he falls into a deep Sadness, breathes with much Difficulty, his Pulse grows feeble and his Senses dull. At Length he loses all Sense and Motion, and dies, unless speedily relieved. An Aversion to blue and black, and an Affection for white, red and green, are other unaccountable Symptoms of this Disorder.

There is no Remedy but one. While he lies senseless and motionless, a Musician plays several Tunes. When he hits on the Right, the Patient immediately begins to make a faint Motion. His Fingers first move in Cadence, then his Feet: Then his Legs, and by Degrees his whole Body. At Length he rises on his Feet, and begins to dance, which some will do for six Hours without Intermission. After this he is put to Bed, and when his Strength is recruited, is called up by the same Tune to a second Dance.

This is continued for six or seven Days at least, till he is so weak he can dance no longer. This is the Sign of his being cured; for if the Poison acted still, he would dance till he dropt down dead. When he is thoroughly tired he awakes as out of Sleep, without remembring any Thing that is past. And sometimes he is totally cured; but if not, he finds a melancholy Gloom, shuns Men, seeks Water, and if not carefully watched, often leaps into a River. In some the Disorder returns that Time twelve-month, perhaps for 20 or 30 Years. And each Time it is removed as at first. Can even Dr. Mead account for this? ⁹

7. Mention

⁹ Equally unaccountable are the two Relations published some Years since, by a Physician of undoubted Credit. The first is: A Gentleman was seized with a violent Fever, attended with a Delirium. On the third Day he begged to hear a little Concert in his Chamber. It was with great Difficulty the Physician consented. From the first Tune, his Face assumed a serene Air, his Eyes were no longer wild, and the Convulsions ceased. He was free from the Fever during the Concert; but when that was ended, it returned. The Remedy was repeated, and both the Delirium and Fever always

7. Mention was made of the extreme Smallness of some Spiders. But how much smaller are those *Animalcula*, discerned by the *Microscope*? These are in almost all Water. Even in that wherein the best Glasses can discover no Particle of animated Matter, after a few Grains of Pepper, or a small Fragment of a Plant of almost any Kind has been some Time in it, Animals full of Life are produced and so numerous as to equal the Fluid itself in Quantity.

A small Quantity of Water taken from any Ditch in Summer, is found to abound in just such Creatures only larger. Nay any Water, set in open Vessels in the Summer Months, will after a few Days yield Multitudes of them.

These we know by their future Changes are the Fly-worms of Gnats, and several other Sorts of Flies. And we easily judge, they owe their Origin to the Eggs of the Parent-fly there deposited. No doubt then but the Air abounds with other *Animalcula*, as minute as the Worms in these Fluids. And these are the Fly-worms of these *Animalcula*, which after a proper Time spent in that State, will become Flies like those to which they owe their Origin.

The Waters in which different Liquors are infused afford a proper Matter for the Worms of different Species of Flies. And some of these doubtless are viviparous, others oviparous. This may Occasion the different Time taken up for producing Insects in different Fluids.

ceased during the Concerts. In ten Days, Music wrought an entire Cure and he relapsed no more.

The other Case is that of a Dancing-Master, who, thro' Fatigue, fell into a violent Fever. On the fourth or fifth Day he was seized with a Lethargy, which after some Time changed into a furious Delirium. He threatened all that were present, and obstinately refused all the Medicines that were offered him. One of them saying, that perhaps Music might a little compose his Imagination, a Friend of his took up his Violin, and began to play on it. The Patient started up in his Bed, like one agreeably surprized, and shewed by his Head (his Arms being held) the Pleasure that he felt. Those who held his Arms, finding the Effects of the Violin, loosened their Hold, and let him move them, according to the Tunes. In about a Quarter of an Hour, he fell into a deep Sleep. When he awaked, he was out of all Danger.

Fluids. Those proper for the Worms of a viviparous Fly, will be soonest full of them. Whereas a longer Time is required to hatch the Eggs of the Oviparous.

Now every Animalcule being an organized Body, how delicate must the Parts be, that are necessary to make it such, and to preserve its vital Actions? It is hard to conceive, how in so narrow a Compass, there is an Heart, to be the Fountain of Life, Muscles necessary for its Motions, Glands, to secrete its Fluids, Stomach and Bowels to digest its Food, and other innumerable Parts, without which an Animal cannot subsist. And every one of these must have Fibres, Membranes, Coats, Veins, Arteries, Nerves, and an infinite Number of Tubes, whose Smallness exceeds all Efforts of Imagination. And yet there are Parts that must be infinitely smaller than these, namely the Fluids that move thro' them, the Blood, Lymph and Animal Spirits, whose Subtility even in large Animals is incredible.

As to some of the Animalcules observed by *Leuwenhoeck*, he computed, that 3 or 400 of them placed close together in a Line, would only equal the Diameter of a Grain of Sand. Twenty Seven Millions then of these Animals equal in Bulk a Grain of Sand!

But *Hartsoeker* carries the Matter still farther. " If says he, according to our present System of Generation, all Animals were formed from the Beginning of the World, and inclosed one within another, and all of them in the first Animal of each Species: How minute must the Animalcula produced now, have been at the Beginning? "

8 Even the meanest and most contemptible of Insects, shews the Wisdom of its Creator. *Fleas*, for Instance, deposit their Eggs only on such Animals, as afford them a proper Food. These hatch into Worms of a shining Pearl Colour, which feed on the Scurf of the Cuticle. In a Fortnight they are very active, and if disturbed, suddenly roll themselves into a Ball. Soon after they begin to creep, with a very swift Motion. When arrived at their full Size, they spin a thread out of their Mouth, wherewith they form themselves a Case. After a Fortnight's Rest here, each of them bursts out a perfect Flea, leaving

leaving its Exuviae behind. It is Milk-white 'till the second Day before its Eruption: Then it changes Colour and gets Strength, so that upon its first Delivery, it springs nimble away.

9. A *Louse* also affords to our Observation, a very delicate Structure of Parts. It is divided into the Head, the Breast and the Tail. In the Head appear two fine, black Eyes, with a Horn that has five Joints and is surrounded with Hairs, standing before each Eye. From the Nose projects in a Sheath the Piercer or Sucker, which it thrusts into the Skin. This is judged to be seven hundred Times finer than an Hair. It has no other Mouth than this.

The Skin of the Breast is transparent, and from the under part of it proceed six Legs, each having five Joints; each Leg is terminated by two Claws, which it uses as we would a Thumb and middle Finger.

If one of them when hungry be placed on the Back of the Hand, it will thrust its Sucker into the Skin, and the Blood it sucks may be seen passing in a fine Stream to the Fore-part of the Head. Falling into a roundish Cavity there, it passes on to another Receptacle in the Middle of the Head. Thence it runs to the Breast, and then to a Gut which reaches to the hinder Part of the Body, where in a Curve it turns again a little upward. It then stands still, and seems to undergo a Separation: Some of it becoming clear and watry, while other black Particles pass down to the Anus.

Lice are not Hermaphrodites, and the Males have Stings, which the Females have not. A Female lays in twelve Days an hundred Eggs, which hatch in six Days.

Suppose

* Minute Animals are found proportionably much stronger and more active than large ones. The Spring of a Flea in its Leap vastly exceeds any Thing greater Animals are capable of. Mr. De Lisle has computed the Velocity of a little Creature, which ran three Inches in half a Second. Now supposing its Feet to be the fifteenth Part of a Line, it must then, in order to travel over such a Space in such a Time, make five hundred Steps in the Space of three Inches: That is, it must shift its Feet five hundred Times in a Second, or in the ordinary Pulsation of an Artery. What is the Motion of any large Animal, in Comparison of this? Or what is the Swiftness of a Greyhound or a Race-horse, to that of such an Animalcule?

Suppose these produce fifty Males, and as many Females: These Females coming to their full Growth in eighteen Days, may each in twelve Days lay an hundred Eggs more. And these in six Days more may produce a young Brood of five thousand. So swiftly do these Creatures multiply!

Most Animals are subject to Lice, but each of a different Kind, and none of them like the Human. Nay even Insects are not free. Beetles, Ear-wigs and Snails are particularly subject to them. Numberless little red Lice are often seen about the Legs of Spiders. A Sort of whitish Lice are common on Bees. They are also found on Ants.

Fishes, one would think, living in the Water, and perpetually moving to and fro, should be free from Lice. But they have their Sorts too, which nest under their Scales, the Salmon in particular. Beside which, there are frequently found great Numbers of long Worms, in the Stomach and other Parts of Fish. And these work themselves so deeply into their Flesh, that they cannot easily be got out.

Many Insects are bred in the Nostrils of Sheep. One may take out twenty or thirty rough Maggots at a Time. A rough, whitish Maggot is found also within the Intestinum Rectum of Horses. Others are generated in the Backs of Cows, which at first are only a small Knot, being an Egg laid there by some Insect. Afterward it grows bigger, and contains a Maggot, lying in a purulent Matter.

In *Persia* slender Worms six or seven Yards long, are bred in the Legs and other Parts of Men's Bodies. Yea, there have been divers Instances, of Worms taken out of the Tongue, Gums, Nose and other Parts, by a Person of *Lancaster*, before many Witnesses.

10. A very extraordinary Kind of Insect, is that which is called a *Death-watch*, because it makes a Noise like the beating of a Watch. They are of two Kinds. One is a small Beetle, somewhat more than a quarter of an Inch long, of a dark brown, and spotted, having a large Cap on the Head, and two Feelers springing from beneath the Eyes. *Dr. Denham* observed it to draw back its

its Mouth, and beat with its Forehead. He kept two, a Male and a Female, in a Box, for some Months, and could bring one of them to beat when he pleased, by imitating its beating. And he soon found this ticking to be the Way, whereby they wooed one another.

The other Kind is a greyish Insect like a Louse, which beats some Hours together without Intermiſſion; and that slowly, whereas the former beats only seven or eight Strokes at a Time, and much quicker. It is very common in Summer in all Parts of our Houses, is nimble in running to shelter, and shy of beating, if disturbed; but is free to beat, and to answer your beating if you do not shake the Place where it lies. This commonly, if not always beats, either in or near Paper. It is at first a small, white Egg, like a Nit. It hatches in March, and creeps about with its Shell on. It is then smaller than the Egg itself, but soon grows to the perfect Size.

11. A *Female-Fly*, within four and twenty Hours after her Congress with the Male, begins to deposit her Eggs, on some Substance proper to give Nourishment to the Worm that is to be produced. These Eggs in general are white and oblong. But there are some of them which are singular. To describe one Species of them may suffice, the Eggs laid on Hog's-dung.

They are white and oblong, but of a peculiar Make. At one End of each of these Eggs, between that End and the Middle, are two little Wings, standing out on either Side. As soon as the Fly has laid her Eggs, she thrusts them into the Dung. This keeps the Coat of the Egg soft; otherwise the Embryo could never get out. But if the whole Egg were thrust in, the Creature would be suffocated, as soon as it is hatched. Therefore Part only is to be immersed, and Part to be left out. And this is admirably provided for by these Wings. For when the Female thrusts in the Egg, it easily enters at the smaller End, which is the Part first protruded from her body: But it stops at the Wings, and so the upper Part remains open to the Air.

Some Species of Flies fasten their Eggs to the Sides of Vessels of Water. All these Eggs have a thin Flake running down the two Sides diametrically opposite. So that they

they look as if they were inclosed in a Frame. The Use of this Frame is, to hold the Body of the Egg more firmly to the Side of the Vessel. Those Eggs which have it not, are deposited by the Female-fly with a viscous Matter about them.

Some Flies lay their Eggs in the Bodies of Caterpillars. These are at great Pains to carry those Caterpillars to the Places where it is proper their Eggs should be hatched. There is one Species whose Worm can never succeed, unless it be both bred in the Caterpillar, and that Caterpillar buried under Ground. To this Purpose the Parent, when ready to lay her Eggs, forms a Hole in the Ground, and covers it with a little Clod. Then she goes in search of a proper Caterpillar, perhaps one much larger than herself, which nevertheless she drags to her Hole. This she uncovers and goes in to see if all is right. Then she goes and draws the Caterpillar in, deposits her Eggs in his Flesh, and stops up the Hole with several Pellets of Dirt and Dust, carefully rammed in between. When the Worms are hatched, they feed on the Flesh of the Caterpillar till they are full grown. Then they change into *Aurelia*, and afterward into the Form of the Parent-fly: In which State they easily make their Way out of the Ground.

Some of these lay their Eggs in the Bodies of smaller Flies. They often fly with one of them in their Legs, the Head of it being close to their Bellies. They carry these to little Holes in the Ground. In the first they lay their Eggs. Then they bring others, to be Food for their Young when hatched. One Fly is not enough; therefore their Parents carry them more every Day: Crawling backward into the Hole, and dragging in the Flies after them. When the Worms change into *Aurelia*, their Cases are made of the Exuviae of the Flies they have been feeding on.

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12. There

* The Eggs of Insects are usually the Occasion of what are termed Blights. These seldom happen but on the blowing of sharp easterly Winds. Many Insects attend those Winds, and lay their Eggs on proper Plants. Indeed the large Worms or Caterpillars which attend some Blights, seem to be only *hatched* by those Winds. But they probably bring those Swarms of Insects, which occasion the curling of the Leaves of Trees.

11. There are few Insects more prolific than the *Gnat*. All its Changes from the Egg to the perfect Animal are fulfilled in three Weeks or a Month: And there are usually seven Generations of them in a Year, in each of which the Parent lays 2 or 300 Eggs. These she ranges in the Form of a Boat, and each Egg is shaped like a Nine-pin. The thicker Ends of these are placed downward. They are firmly joined together by their Middles, and their narrower Parts stand upward.

Viewed with a Microscope, the larger End is observed to be terminated by a short Neck, the End of which is bordered by a Kind of Ridge. The Neck of each is sunk in the Water, on which the Boat swims: For it is necessary it should keep on the Surface, since otherwise the Eggs could never be hatched.

The

Every Insect feeds on one Plant and no other. On this only it lays its Eggs. Hence it is, that one Kind of Tree only is blighted, and the rest escape. All Trees then cannot be blighted at once, unless one Wind could bring the Eggs of all Insects, with as many different Degrees of Heat and Cold, as are required to hatch and preserve each Species.

And what tho' we do not always perceive Animals in Blights? By Microscopes we discover Animalcula, a Million Times less than those that are perceivable by the naked Eye. The gentle Air may waft these from Place to Place: So that it is no Wonder if they are brought to us from *Great Turkey*, even the cold Air of which may give them Life, and from whence there is not so much Sea as to suffocate them in its Passage, by the Warmth and Saltness of its Vapours.

Trees are preserved from Blights, by sprinkling them with Tobacco-dust or Pepper-dust; which are Death to all Insects.

But one Kind of Blight is caused, merely by long-continued, dry, easterly Winds. These stop the Perspiration in the tender Blossoms, so that in a short Time they wither and decay: Soon after, the tender Leaves are affected; their perspiring Matter becoming thick and glutinous, so as to be a proper Nutrient to the Insects, which are then always found upon them. In this Case, the Insects are not the Cause, but the Effect of the Blight.

It is a Kind of Blight that produces *Galls*, which are the Buds of Oaks swelled out. The Cause is, into the Heart of the tender Bud, a Fly thrusts one or more Eggs. This Egg soon becomes a Worm and cuts itself a little Cell in the Pith of the Bud, which would have grown into a Branch. The Sap, which was to nourish that Branch, being diverted into the remaining Parts of the Bud, these grow large and flourishing, and become a Covering for the Cell of the Insect.

The ranging these in so exact Order, requires the utmost Care in the Parent. Gnats lay their Eggs in the Morning Hours, and that on such Waters, as will give Support to their Young. Here the Parent places herself on a small Stick, a Leaf, or any such Matter near the Water-Edge, in such a Manner, that the last Ring but one of her Body, touches the Surface of the Water. The last Ring of all, where there is the Passage for the Eggs, is turned upward, and every Egg is thrust out vertically. When it is almost disengaged, she applies it to the Side of the Cluster already formed: To which it readily adheres by Means of a viscons Matter wherewith they are covered.

The great Difficulty is, to place the first laid Eggs in a proper Position to receive the rest, and to sustain themselves and them, in a proper Direction. These she with great Precaution places exactly, by Means of her Hinder Legs. And when a sufficient Number of them

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are

Not only the Willow and some other Trees, but Plants also, Nettles, Ground-ivy and others, have such Cases produced upon their Leaves. The Parent-Insect, with its stiff Tail, bores the Rib of the Leaf when tender, and makes Way for her Egg into the very Pith. Probably she lays it there, with some proper Juice, to prevent the Vegetation of it. From this Wound arises a small Excreescence, which when the Egg is hatched grows bigger and bigger, as the Worm increases, swelling on each Side the Leaf, between the two Membranes. This Worm turns afterwards to an Aurelia, and then to a small, green Fly.

The *Apple-Galls*, wherewith we make our Ink, are of this Number, being only Cases of Insects, which gnawed their Way out, thro' the little Holes we see in them.

For a Sample of the tender Balls, see the Balls as round, and sometimes as big as small Musket-bullets, growing under Oaken-leaves, close to the Ribs, of a greenish, yellowish Colour. Their Skin is smooth, with frequent Risings therein. Inwardly they are very soft and spongy; and in the very Center is a Case, with a white Worm therein, which afterwards becomes a Fly. As to this Gall, there is one Thing peculiar. The Fly lies all Winter within this Ball, and does not come to Maturity 'till the following Spring. In the Autumn these Balls fall to the Ground with their Leaves. Yet the Insect inclosed in them, is fenced against the Winter-Frosts, partly by other Leaves lying upon them, and partly by the thick, spongy Wall, afforded by the Galls themselves.

are arranged, all the rest is easy: Inasmuch as these are a firm Support, to all that follow them.

13. A *Cicadula* is a small Insect found in *May* and *June*, on the Stalks and Leaves of Plants, in a Kind of Froth, commonly called *Cuckoo-spit*. This Froth is not from the Plant, but the Mouth of the Animal; and if it be gently wiped away, will be presently seen issuing out of its Mouth, 'till there is as large a Quantity of it as before. They are of the Shape of a Louse, some being whitish, some yellowish, and others green. They often change their Skins, while they live in this Froth, and only creep a little. But when they leave the Plant they hop and fly, having Wings which cover the whole Body.

14. The most singular Part of the Life of a *Drone-Fly*, is that it passes in the Form of a Worm. It is then distinguished from all other Worms by its long Tail: At different Times this is indeed of different Lengths; but it is always longer than the Worm itself. It is round, smooth, and very small at the Extremity; sometimes no thicker than a Horse-hair. To know the Use of this Tail, we must first know the Nature of the Worm itself. It is an Aquatic, and never leaves the Water, 'till it changes into its Fly-State. They lie in Multitudes in the Mud at the Bottom of Vessels of stinking Water. Put them into Vessels of clean Water, and they will soon shew the Use of their Tails. Tho' they live under Water, they cannot live without breathing fresh Air. This is the End to which their long Tails serve. For even while they lie buried in the Mud, their Tails are extended to the Top of the Water, and being open at the Extremity, let Air into their Bodies. And as soon as they are in a Vessel of fresh Water, they get to the Bottom and thrust up their Tails to the Surface. They can lengthen them at Pleasure: To be assured of this, you need only pour in more Water. The Worms then lengthen their Tails proportionably, in Order to breathe from the Surface: By adding more and more Water you will find, they can extend their Tails to the Length of five Inches: An extremely remarkable Length for a Creature little more than half an Inch long. Beyond five Inches however they cannot go. And if you make the Water
of

of a greater Depth, they leave the Bottom, and either travel up the Sides of the Vessel to a proper Height; or else swim in the Water, at the Depth of five Inches.

No Species of Flies is more remarkable, than the larger *Fire-fly* of *Jamaica*. It is above an Inch long, and proportionably broad. Most of its internal Parts are luminous; only the Thickness of the Cover hinders its appearing. But on forcing the Rings that cover the Body a little asunder, Light issues from all the Entrails. The Head has two Spots just behind the Eyes, which emit Streams of strong Light. But tho' these flow naturally from the Insect, yet it has a Power of interrupting them at Pleasure. And then these Spots are as opaque as the Surface of the Body.

A Person may read the smallest Print by the Light of one of these Insects, if held between the Fingers, and moved along the Lines, with the luminous Spots over the Letters. They are seldom seen in the Day, but wake with the Evening, and move and shine most Part of the Night. They readily fly toward each other. Hence the Negroes have learned, to hold one between their Fingers and wave it up and down, which others seeing fly directly toward it, and pitch upon the Hand. They are so torpid by Day, it is hard to make them discover Signs of Life; and if they do, they presently relapse into the same State of Insensibility. As long as they remain awake, they emit Light: But they are vigorous only in the Night.

16. One more Insect of the Fly Kind, we cannot pass by unnoticed; The *Ephemeron*, or Fly that lives but Part of a Day. It appears usually about Midsummer. It is produced about six in the Evening, and dies about eleven. But before it becomes a Fly, it exists three Years as a Worm in a Clay Case. It never eats from the Time of its Change to its Death, nor has any Organs for receiving or digesting Food. The Business of its Life is summed up in few Words. As soon as it has dropt its Clay-Coat, the poor, little Animal being now light and agile, spends the rest of its short, winged State, in frisking over the Waters. During this the Female being impregnated, drops her Eggs upon the Water. These sink to the Bottom, where they are

hatched by the Heat of the Sun into little Worms, which make themselves Cases in the Clay, and feed on the same, or on what the Waters afford, without any Need of parental Care. Thus they are Inhabitants of the Water, 'till the Time comes for shaking off their Shell, and emerging into Air.

17. The Eggs of *Butterflies* do not increase in Bulk while in the Body of the Female. As soon as they are impregnated by the Male, they are ready to be laid. But this requires some Time, both because of their Number, and the Nicety with which she arranges them. This indeed is the whole Business of her Life. For when they are laid, she dies.

The Female does not deposit them at random, but searches out that Sort of Plant, which the Caterpillars can feed on as soon as they are hatched. Neither does she scatter them irregularly and without order, but disposes them with perfect Symmetry, and fastens them together by a viscid Liquor discharged from her own Entrails. And those Species whose hinder Part is covered with long Hairs, gradually throw them all off, and therewith make a Nest, wherein the Eggs are kept safely, 'till the Time of their hatching.

18. Some *Caterpillars* are hatched in the Spring, as soon as the Leaves they are to be fed on begin to bud. After thirteen Days, they change into *Aureliae*, and having past three Weeks in that State, they issue forth winged, with all the Beauty of their Parents: Their Wings are scarce dry, before they seek to propagate their Species. This done, the Male dies. The Female lives only to deposit her Eggs, and then follows him. Nature never intending they should eat in this State, has given them no Organs for it: So that they would soon die of Hunger, could they escape those great Devourers of them, the Birds.

Caterpillars are of no Sex, it not being their Business to propagate, 'till they commence *Butterflies*. Yet many of them are not so harmless as they seem; for they destroy their Fellows, whenever they can. Put twenty Caterpillars of the Oak together in a Box, with a sufficient Quantity of Leaves, their natural Food. Yet their

their Numbers will decrease daily, 'till only one remains alive. The Stronger seizes the Weaker by the Throat, and gives him a mortal Wound. When he is dead, the Murderer begins to eat him up, and leaves only the Skin with the Head and Feet. But this is not the Case of all. Many Species live peaceably and comfortably together.

Yet even these are exposed to Dangers of a more terrible Kind. The Worms of several Sorts of Flies, continually prey upon them. Some are upon, some under the Skin, and both eat up the poor, defenceless Animal alive.

It is surprizing to see with what Industry these little Creatures weave the Cases, in which they pass their Aurelian-state. Some are made of Silk, mixt with their own Hair, with Pieces of Bark, Leaves, Wood or Paper. There is one Sort that builds in Wood, and gives its Case an Hardness greater than that of the Wood itself. This is the Caterpillar of the Willow, which is one of those that eat their Exuviae. He has sharp Teeth, where-with he cuts the Wood into a Number of small Fragments. These he unites together into a Case, by Means of a peculiar Silk, which is a viscous Juice that hardens as it dries. In Order to make this Silk enter into the very Substance of the Fragments, he moistens every one of them, by holding them successively in his Mouth for a considerable Time. In this firm Case he is afterward to be included till he becomes a Butterfly. But how shall a Creature of this helpless Kind, which has neither Legs to dig, nor Teeth to gnaw, get out of so firm and strong a Lodgement as that wherein it is hatched? Nature has provided for this also. As soon as it is hatched, it discharges a Liquor which dissolves the viscous Matter that holds the Case together, so that the Fragments fall in Pieces of themselves. And accordingly, near its Mouth, there is always found a Bladder of the Size of a small Pea, full of this Liquor.

Some Caterpillars spin all the Way they walk, a thread of Silk which marks their Journey. Now what End does this serve? A little Observation will shew. Trace one of them till he chanceth to fall, and you will see the
Use

Use of this Thread. Being fastened to the Leaves and Twigs, it stops the Creatures Fall. Nor is this all. It can also by means of this Thread, re-ascend to the Place from whence it fell. And when it is safe got up again, it continues its Motion as before.

Another curious Artifice is that by which the same Species of Caterpillars make themselves Cases of Leaves before they change into Aureliae. The nicest Hands could not roll these up so elegantly, as they do without Hands or any Thing like them. They perform it thus, The Caterpillar places itself on the upper Side of a Leaf, so far from the Edge that he can reach it with his Head. Turning himself round, he then brings the Edge of the Leaf, to the point just opposite to it. It next draws Lines from this Edge of the Leaf to that Point: And doing this all the Way along the Leaf, its narrowness toward the Point makes it form a close Case there. It strengthens the first bending of the Leaf, by many parallel Threads, and then fastening other Threads to the back Part of the Leaf, draws them as tight as it can. The Case is then formed. The same Method repeated makes the additional Cases, five or six over each other. And every one of these is sufficiently strong, so as to make the inner ones useless. He then enters his Cell and undergoes his Change. Meantime his Covering serves him also for Food. For so long as he has Need to eat, he may feed upon the Walls of his Castle: All of which may be eaten away, except the outer one of all. Probably every Caterpillar makes his Case thick enough to serve the necessary Calls of his future Hunger.

Many Species of Butterflies lay a great Number of Eggs in the same Place. These all hatch very nearly at the same Time. And one would naturally suppose, that the young Brood of all, would be inclined to continue and live together. But it is not so, the different Species have different Inclinations. Some keep together from the Time they are hatched, till they change into Aureliae. Others separate as soon as able to crawl, and hunt their Fortune single. And others live in Community till a certain Time, and then each shifts for itself.

Those

Those that live wholly together, begin by forming a Line with their little Bodies upon a Leaf; their Heads all standing even, and in this Manner they move and eat together. And often there are several Ranges of this Sort, which makes so many Phalanxes, and eating to the Leaf they stand on, with perfect Equality.

Many do this while young, which when they grow large, make one common Habitation, surrounded by a Web, which is the joint Work of all: Within which, each has a Nest of its own Spinning.

When they have made their common Lodging, each takes its Course over the Tree or Bush for Food. Thus many hundreds of them form a regular Republic. The separate Cell of each, is finally the Place, where it passes its Change into the Aurelia and perfect State. But many Species do not separate even then; but are found in their Aurelia-State all huddled together. Numbers of their Cases making one confused Mass.

One Thing more is highly observable in them. The Regularity of their Marches. They are exactly obedient to their Chief. When they change their Quarters, One marches single first. Two others follow, and keep their Bodies very nicely in the same Position with his. After these there follows a large Party. These regulate their Motions by the former. And so the Order is continued, thro' the whole Company. When the Leader turns to the right or left, the whole Body does the same instantly. When he stops, they all immediately stop, and march again the Moment he advances.

19. The outward Covering of the Body is, in many Animals changed several Times: But in none more frequently than the Caterpillar. Most of these throw it off at least once in ten Days. Indeed in the whole Insect Class, the most numerous of all animated Beings, there is scarce one which does not cast its Skin, at least once, before it arrives at its full Growth. But the Caterpillar changes more than his Skin: Even the outward Covering of every, the minutest Part of its Body. And what they throw off has the Appearance of a complete Insect, presenting us with all the external Parts of a living Animal. If the Caterpillar be of the hairy Kind, the

the Skin it throws off is hairy, containing the Covering of every Hair. And even the Claws and other Parts that are not visible without a Microscope, are as plain in this as in the living Animal. But what is a more amazing is, that the solid Parts of the Head, the Skull and Teeth are distinguishable therein. The throwing off an old Skull and Teeth, to make Way for new ones, is an Act beyond all Comprehension! A Day or two before, the Creature refuses to eat, and walks very slowly, or not at all. He turns from Side to Side, and often raises his Beak, and gently depresses it again. He frequently raises his Head, and strikes it down rudely against any Thing he stands upon. Frequently the Fore-part of the Body is raised from the Place, and thrust very briskly backward and forward, three or four Times together. There are likewise distinct Motions within every Ring. These are severally inflated and contracted alternately, by which the Skin is loosened from them; till by this Means, and its remaining without Food, the Body is quite disengaged from its Covering.

When this Time approaches, all the Colours of the Skin grow faint and lose their Beauty, receiving no Nourishment from the Body. And as the Creature continues swelling and shrinking, the Skin, being no longer supple, cracks along his Back. The Crack always begins, at the second or third Ring, from the Head. As it opens, the new Skin is seen within. This opening he easily enlarges, thrusting his Body like a Wedge, out of the Slit, till he lengthens it thro' four Rings. Then he has Room to draw out the whole Body. First, the Head is by several Motions loosened, drawn out of the old Skull, and raised thro' the Crack: This is then laid softly on the old Skin of the Part. By the same Motions the Tail End is disengaged, drawn out and laid smoothly on the old Skin. It takes the Animal several Days, to prepare for the last Operation. But when the Crack is once made, the whole remaining Work is done in less than a Minute.

The Hairs found on the cast Skins of the hairy Caterpillars seem at first, like the other Part of the Exuviae, to be only the Covering of the Hairs inclosed. But that

is not the Case. They are solid Things themselves, not barely Coverings. In truth, the Creature when first hatched, has all its Skins perfectly formed, one under another, each furnished with its Hairs, so that the old ones fall off with the old Skins. And probably the erecting these is one great Means of forcing off the old Skins.

Perhaps the same Sort of Mechanism is used even by those Caterpillars, which do not appear to be hairy. For they really are so as the Microscope shews. When the upper Skin of one just ready to change, is slit longitudinally in the Place where the Crack would be, the Skin may be taken off; and it is easily seen, how the new one lies below. The Hairs are disposed in the nicest Manner, for lying smooth under the upper Skin. They grow in separate Tuffs, which never lie one upon another, but together form one Surface.

It is remarkable, that immediately after this Change they appear much larger than they did before. And they really are so. The very Head and Skull are greatly larger than before the Change. The Operation of the Cray-fish in changing its Shell, may explain this. This also is found considerably larger, when out of the Shell than before. In both Cases, the Body had grown so much, that it was too big for its Covering. However while it remained in it, the Parts were compressed, and forced to lie in that narrow Room. But as soon as that Covering is off, every Part distends itself to its proper Size.

Indeed so large a Skull, being a hard Substance in the Caterpillar, could not have been compressed into a smaller. But the Fact is, the new Skull never hardens till the Change approaches, and then imperfectly. At the same Time it necessarily takes from the Place it is in, an oblong Form. In this Shape it is found a few Hours before the old Skin is cast off; not inclosed within it, but extended under the Skin of the first Ring of the Body. When the old Skull is thrown off, the new one soon hardens and takes its proper Figure.

We call the Creature hatched from the Egg of a Butterfly, a Caterpillar. But it is a real Butterfly all that Time.

Time, A Caterpillar changes its Skin four or five Times, and when it throws off one, appears in another of the same Form. But when it throws off the last, as it is now so perfect, as to need no farther Nourishment, so there is no farther need of Teeth, or any other Parts of a Caterpillar.

'Tis plain from hence, that the Change of a Caterpillar into an Aurelia, is not the Work of a Moment, but is carrying on, from the very Time of its hatching from the Egg. But while the Butterfly lies in the Body of the Caterpillar, its Wings are long and narrow, and wound up into the Form of a Cord, and the Feelers are rolled up on the Head. The Trunk also is twisted up and laid on the Head, but in a very different Manner, from what it is in the perfect Animal, or indeed in the Aurelia.

A Butterfly then in all its Parts, is in the Caterpillar in all its States. But it is more easily traced, as it comes nearer the Time of being changed into an Aurelia. The very Eggs hereafter to be laid by the Butterfly, are to be found not only in the Aurelia, but even in the Caterpillar, all arranged in their natural, regular Order. In the Caterpillar indeed they are transparent : But in the Aurelia, they have their proper Colour.

As soon as the Limbs of the Butterfly are fit to be exposed to the more open Air, they are thrown out from the Body of the Caterpillar, surrounded only with thin Membranes. And as soon as they arrive at a proper Degree of Strength and Solidity, they break thro' these and appear in their perfect Form.

The Animal then creeps a little on, and there rests : The Wings being quite folded up. But by Degrees they expand, and in less than Half an Hour, appear in all their Beauty.

20. The

The Kind of Sea Shrubs, as they are formerly accounted, usually termed *Corallines*, are in Reality no other than Cases for various Species of Insects. A French Gentleman was the first who discovered this. Observing a great Number of Insects lodged in several Parts of the e marine Productions, he soon inferred, That these were only Cases made by these Creatures for their Habitations : And

20. The *Ant* lays Eggs like Flies, from which are hatched small Worms without Legs. These are sharp at one End, and blunt at the other: After a short Time they change into large, white *Aureliæ*; vulgarly called

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many of them have since been found to be the Covers of Marine *Polypi*: A strange Kind of Animal, so nearly partaking the Nature of some Vegetables, that new, perfect Polypes, perpetually grow like Branches from the Trunk of the Parent. Yea, if a Polype be cut in Pieces, every Piece will grow into a perfect Polype.

A late Writer informs us, "At the Isle of *Shepp*, I had the Opportunity of seeing several branched Corallines, alive in Sea-water, by the Help of a commodious Microscope, and was fully assured, that these apparent Plants were real Animals, in their proper Cases, which were fixt to the Shells of Oysters, and other small Shell-fish. And at *Brightbelms*, I saw those Corallines in Motion, whose Polypes are contained in Cups, supported by a long Stem that appears full of Rings, or twisted in Form of a Screw. In the Middle of the transparent Stems or Cases, I could easily discern the Thread like tender Part of the Animals.

On several Parts of these Corallines there are little Bodies, which thro' the Microscope appear as so many Bladders. To the Use of these I was quite a Stranger before; but I now discovered, they are Habitations of young Polypes, which are produced here and there on the Sides of the Parent, as in the Fresh-water Polypes. Only in the marine ones they are protected by this vesicular Covering. These Vesicles appear at a certain Season of the Year, according to the different Species of Corallines, and fall off, like the Blossoms of Plants, as soon as the Polypes arrive at Maturity.

But Corallines are Cases not of Polypes only, but of various Sorts of Animals: Which occasions their being made of various Materials, and in great Variety of Forms. Some are united closely and compactly together, forming irregular Branches, like Trees. Others rise in Tufts, like the tubular Sort of Plants, distinct from one another. Some *Maltese* Corallines are of a peculiar Kind. The Animals inclosed in these, resemble the many-legged Spiders, usually known by the Name of *Scolopendre*. Their outside Coats are formed of an ash-coloured earthy Matter, and closely united to an inner Coat, which is tough, horny, transparent, and extremely smooth. The Cavity of the Tube is quite round, tho' the Animal is of a long Figure, like a Leech extended. It can turn itself in this Tube, and move up and down the better to attack and secure its Prey.

It has two remarkable Arms. The left much larger than the right. These are doubly feathered. The Number of its Feet on each Side of the Body exceeds an hundred and fifty.

Ants-Eggs : Whereas they are larger than the Ants themselves. They move these at their Pleasure. When an Ant's Nest is disturbed, and the Aureliæ scattered abroad, the Ants are at infinite Pains to gather them and make them a Nest again. Nay, those of one Nest will often do this for the Aureliæ of another.

At the Bottom of an Ant's Nest, which is built with small Pieces of dry Earth, there is always a large Quantity of Eggs, Worms and Aureliæ. The Aureliæ are covered only with a thin Skin, and if opened shew the Ant in its several Stages toward Perfection.

In every Nest, as in every Bee-hive, there are three Kinds of the Insect, Males, Females, and working Ants, or Labourers. These last are neither Male nor Female, nor have any Business, but taking Care of the young Brood. Male Ants have four Wings and three lucid Points on their Head, and their Eyes are larger than those of the Females or Labourers. They are not found in the Nests at all Seasons, but only at particular Times. It seems they are killed, (like Drone Bees) as soon as the Season for impregnating the Females is over.

The Body of the Female is larger and thicker than that of the Male, or Labourer; and contains a great Number of Eggs, placed in regular Lines. She has also the three lucid Points on her Head, which seem to be three Eyes.

The Ant examined by the Microscope appears a very beautiful Creature. Its Head is adorned with two Horns, each having twelve Points. Its Jaws are indented with seven little Teeth, which exactly tally. They open Sideways exceeding wide, by which Means the Ant is often seen grasping and carrying away Bodies of three Times its own Bulk. It is naturally divided into the Head, the Breast and the Belly, each joined to the other by a slender Ligament. From the Breast proceed three Legs on each Side. The whole Body is cased over with a sort of Armour, so hard as scarce to be penetrated by a Lancet, and thick-set with shining, whitish Bristles.

They

They bring out not Corn, but their Young, every Day, and spread them near their Nest, in little Heaps, on a Kind of dry Earth, provided for that Purpose. They carry them back at Night. But it is observed, they never bring them out, unless in a Day that promises to be fair. In the Prognosticks of this they shew great Sagacity. Where it is dangerous to expose them in the Day Times by Reason of the Birds, they vary their Rule, bringing them out in the Night, and carrying them back in the Morning.

They do not eat at all in Winter, but sleep like most other Insects. There is a strait Hole in every Ants Nest, about half an Inch deep; after which it goes sloping into their Magazine, which is a different Place from that where they eat and rest. Over the Hole they lay a flat Stone or Tile, to secure them from their great Enemy the Rain. In a fair Day, the Hole is open; but when they foresee it will rain, and every Night, the Cover is drawn over, with great Ingenuity as well as Labour. Fifty of the strongest of them surround the Stone, and draw and shove in Concert. The like Pains they take every Morning, to thrust it back again.

An Ant never goes into any Nest but her own; if she did, she would be severely punished. And if she returned again after this Warning, the others would tear her in Pieces. Therefore they never attempt it, but in the last Extremity: Sometimes they will rather suffer themselves to be taken.

Ants do not bite, as is vulgarly supposed. But Red Ants have a Sting, which expresses a corrosive Liquor, that raises a slight Inflammation. The black Ants have no Sting.

On opening an Ant-hill, a great Quantity of Eggs is usually found. They look like the Scatterings of fine Salt, and are too minute to be seen distinctly by the naked Eye. Thro' a Microscope they appear like the Eggs of small Birds, and are as clear as the Air-bladder of Fishes. They lie in Clusters under Cover of some light Earth. The Ants seem to brood over them, till

every Granule is hatched into a Worm, not much larger than a Mite. In a short Time these turn yellowish and hairy, and grow to near as big as their Parent. They then get a whitish Film over them, and are of an oval Form. If this Cover be opened after some Days, all the Lineaments of an Ant may be traced; tho' the whole is transparent, except the Eyes, which are two dark Specks.

The Care these Creatures take of their Young is amazing. Whenever a Hill is disturbed, all the Ants are found busy, in consulting the Safety, not of themselves, but of their Offspring. They carry them out of Sight as soon as possible; and will do it over and over, as often as they are disturbed. They carry the Eggs and Worms together in their Haste: But as soon as the Danger is over, they carefully separate them, and place each by themselves, under shelter of different Kinds, and at various Depths, according to the different Degrees of Warmth which their different State require.

In the Summer they every Morning bring up the Aureliae near the Surface of the Earth. And from ten in the Morning till about five in the Afternoon, they may be found just under the Surface. But if you search at eight in the Evening, they will be found to have carried them all down. And if rainy Weather be coming on, they lodge them at least a Foot deep.

21. One of the most dreadful Enemies of the Ants is the *Formica-leo* or *Ant-Eater*: It is soft as a Spider, but has in its Form some Resemblance of a Wood-louse. Its Body is composed of several Rings: It has six Legs, four joined to the Breast; and the other Two to a long Part, which may be termed the Neck. Its Head is small and flat, and it has two remarkable Horns; the Sixth of an Inch long, as thick as a Hair, hard, hollow and hooked at the End. At the Origin of each of these Horns, it has a clear and bright black Eye.

He is not able to hunt after Prey, nor to destroy large Insects. He can only insnare such as come by his Habitation, and of these, few are such as he can manage.

All

All the winged Tribe escape by flight, and those that have hard Shells are of no use to him. The smallness of the Ant, and its want of Wings, make it his destined Prey. The Manner wherein he proceeds is this. He usually encamps under an old Wall for Shelter, and always chuses a Place where the Soil is composed of a light, dry Sand. In this he makes a Pit in the shape of a Funnel, which he does in the following Manner.

If he intends the Pit to be but small, he thrusts his hinder Parts into the Sand, and by Degrees works himself into it. When he is deep enough, he tosses out with his Head the loose Sand which is run down, artfully throwing it off, beyond the Edges of the Pit. Then he lies at the bottom of the small Hollow, which comes sloping down to his Body.

But if he is to make a larger Pit, he first traces a larger Circle in the Sand. Then he buries himself in it, and carefully throws off the Sand, beyond the Circle. Thus he continues running down backward in a spiral Line, and throwing off the Sand above him all the Way, till he comes to the point of the hollow Cone, which he has formed by his Passage. The length of his Neck and the Flatness of his Head, enable him to use the whole as a Spade. And his Strength is so great, that he can throw a Quantity of Sand, to six Inches Distance. He likewise throws away the Remains of the Animals he has devoured, that they may not fright other Creatures of the same Species.

Where the Sand is unmixt, he makes and repairs his Pit with great Ease. But it is not so, where other Substances are mixt with it. If when he has half formed his Pit, he comes to a Stone not too large, he goes on, leaving that to the last. When the Pit is finished, he creeps up backward to the Stone, and getting his Back-side under it, takes great Pains to get it on a true Poise, and then creeps backward with it, to the Top of the Pit.

We may often see one thus labouring at a Stone four Times as big as his own Body. And as it can only move backward, and the Poise is hard to keep, especially up

a Slope of crumbly Sand, the Stone frequently slip when near the Verge, and rolls down to the Bottom. In this Case he attacks it again, and is not discouraged by five or six Miscarriages; but attempts it again, till at length he gets it over the Verge of his Place. Yet he does not leave it there, lest it should roll in again, but always removes it to a convenient Distance.

When his Pit is finished, he buries himself at the Bottom of it in the Sand, leaving no Part above it, but the Tips of his Horns, which he extends to the two Sides of the Pit. Thus he waits for his Prey. If an Ant walk on the Edge of his Pit, it throws down a little of the Sand. This gives Notice, to toss up the Sand from his Head on the Ant; of which he throws more and more, till he brings him down to the Bottom, between his Horns. These he then plunges into the Ant, and having sucked all the Blood, throws out the Skin as far as possible. This done he mounts up the Edges of his Pit, and if they have suffered any Injury, repairs it carefully. He then immediately buries himself again in the Center, to wait for another Meal.

This Creature has no Mouth, but it is thro' its Horns that it receives all its Nourishment. And as they are so necessary for its Life, Nature has provided for the restoring them, in case of Accidents: So that if they are cut off, they soon grow again.

When he has lived his stated Time, he leaves his Pit, and is only seen drawing Traces on the Sand. After this he buries himself under it, and incloses himself in a Case. This is made, of a Sort of Silk with Grains of Sand cemented together by a glutinous Humour which he emits. But this would be too harsh for his Body: So it serves only for the outward Covering. He spins within it one of pure, fine, pearl-coloured Silk, which covers his whole Body. When he has lain sometime in this Case he throws off his outer Skin, with the Eyes, the Horns and all other exterior Parts, and becomes an oblong Worm, in which may be traced the Form of the future Fly. Thro' its transparent Skin may be seen, new Eyes, new Horns and all other Parts of the perfect Animal. The Worm makes it Way about half out of the Case, and so remains

remains, without farther Life or Motion, 'till the perfect Fly makes its Way out of a Slit in the Back. It much resembles the Dragon-fly. The Male then couples with the Female and dies.

22. The Sagacity of *Bees* in making their Combs, cannot be too much admired. The Labour is distributed regularly among them. The same Bees, sometimes carry the Wax in their Jaws, and moisten it with a Liquor which they distil upon it, and sometimes build the Walls of their Cells. But they that form the Cells, never polish them. Others make the Angles exact, and smooth the Surface. The Bits of Wax which are scraped off in doing this, others pick up, that none may be lost.

Those that polish, work longer than those that build the Walls; polishing not being so laborious a Work as building. They begin the Comb at the Top of the Hive, fastning it to the most solid Part thereof. Hence they continue it from Top to Bottom, and from Side to Side. And to make it more solid, they add a Kind of tempered Wax, pretty much like Glue. The Cells are always Six-sided: A Figure, which beside the Advantage it has in common with the Square, of leaving no Vacancies between the Cells, has this peculiar to itself, that it includes a greater Space within the same Surface than any other Figure.

Honey exudes from all Sorts of Flowers, the bitterest not excepted, if they have any Utricle at the Bottom of the Flower-leaves; for there chiefly it is lodged. The Bee thrusting in his Trunk sucks it out, into a small Bladder in his Belly. When this is full he returns, enters one of the Cells, and discharges it there, thro' his Mouth, which he then opens wide, moving his Head at the same Time to and fro. If a Drop be ill-placed, he sucks it up again, and discharges it anew. When a Cell is filled, they stop it up with Wax.

It is a grand Question, Is there any Part of a Plant without Iron? It is certain, Honey is not. And if so delicate an Extract from the finest Part of Flowers, and that farther elaborated in the Bowels of the Insect: If this be not without Iron, we may despair of seeing any Part so.

The

The *Sting* of a Bee or Wasp is a curious Piece of Workmanship. It is an hollow Tube, within which, as in a Sheath, are two sharp-bearded Spears. A Wasp's *Sting* has eight Beards on the Side of each Spear, somewhat like the Beards of Fish-hooks. These Spears in the Sheath lie one with its Point a little before that of the other. One is first darted into the Flesh, which being fixt, by Means of its foremost Beard, the other strikes in too, and so they alternately pierce deeper, the Beards taking more and more hold in the Flesh: Afterward the Sheath follows, to convey the Poison into the Wound. When the Beards are lodged deep in the Flesh, Bees often leave their Stings behind them, if they are disturbed, before they have Time, to withdraw their Spears into their Scabbard.

The *Queen-Bee* is somewhat larger, considerably longer, and of a brighter Red than others. Her Office is, to direct and lead the Swarm, and to raise a new Breed. She brings forth ten, fifteen, or twenty thousand young ones in a Year: So that she may literally be said to be the *Mother* of her People. In an Hive of eight or ten Thousand, there is usually but one *Queen-Bee*.

Drones, or *Males* have no Stings, and are larger and darker-coloured than the working Bees. The Eggs for them are placed in a larger Sort of Cells. They are also Nurses to the Young Brood.

It is certain Bees foresee Rain, tho' we know not how. Hence no Bee is ever caught in a sudden Shower: Unless it be far distant from the Hive, or any Way hurt or sickly.

Thus much may be seen on the Outside of the Hive. But when we look within, how is the Wonder increased! To see so many thousands all so busily at work, and with such admirable Regularity! Nor is there less wonder in observing the Clusters of them, when they take some Rest. Their Method then is, to get together and hang one to another in vast Numbers. When these Clusters are large, they are only shapeless Heaps; when smaller, they are a Sort of Festoon or Garland, each End being fastened to the Branch, and

and the Middle dropping from it. The Manner in which they hang is this. Each with one or both of his Fore-legs lays hold of one or both of the Hinder-legs of the Bee that is next above it.

Thro' a Glass-hive we see, that as the Combs are carried down from the Top to the Bottom of the Hive, each is plac'd parallel to the former, but not touching it, there being a Space between for the Bees to walk. These are their public Streets, and by Means of these they can make use of every Cell. There are likewise Alleys cut from Street to Street, thro' the Substance of the several Combs.

All the Cells are used in common. Some of them contain only Honey, and are covered with a Lid of Wax. These are never touched by any Bee. But other Cells are open, and a Bee is often seen so lodged in one of these, that only its hinder Part appears. The Meaning hereof is, each of these open Cells contains at the Bottom a Bee-worm. Certain Bees duly visit these, plunging their Heads into the several Cells, one after another.

The Fruitfulness of the Female is the less strange, when we consider the Number of the Males. In any Hive there are, at the Season, several Hundreds: In some, two or three Thousand. These are the joint Fathers of the numerous Offspring, and when they have done their Work, are all killed. The Wings of the Female reach only to the third Ring of her Body: Whereas those of all other Bees cover the whole Body. But tho' she is thus easy to be distinguished, yet few have ever seen a Queen-Bee: As she is always close covered in the Hive.

Mr. *Reaumur*, desiring to try, how far the Accounts given of the Homage paid by the others to the Queen-Bee was true, caused a Swarm of Bees to be swept down into a Glass-hive. Among these there was one Female. She was soon distinguished by her Shape, and the Shortness of her Wings. For a while she walked alone at the Bottom of the Hive; the rest seeming to regard nothing but their own Safety. The Female after going twice or thrice up the Sides of the Hive, to the Top of it, where they were hung, at last going in among

among the Cluster, brought down about a Dozen with her. Attended with these, she walked along slowly at the Bottom of the Hive. But the rest continuing at the Top, she went again and again, till they all came down and formed a Circle about her, leaving her a free Passage wherever she turned to walk, and feeding her with the Honey they had gathered for themselves.

The Hive was large enough for more than their Number. However the Female seemed to find, it would not be large enough for the Family she was to produce. So gathering them all about her, she went out and flew to a neighbouring Tree. All followed her, and formed a Cluster about her, in the common Way.

The Bees follow their Queen wherever she goes. And if she be tied by one of the Legs to a Stick, all the Swarm will gather in a Cluster about her, and by removing the Stick may be carried any where.

Nature seems to have informed the common Bees that they are to bring up the Offspring of this Female, therefore they serve her in every Thing. If by any Means she is dirted, all the rest try who shall clean her. And in cold Weather, they cluster together about her, to keep her warm. Nor do they shew this Respect to one Female only. Mr. *Reaumur*, at several Times, put several Females, marked with different Colours, into the same Swarm. And all these were, for a Time, received as well as the proper Female.

The Swarm which leaves an old Hive, have often three or more Females. These have their several Followers. And each with her Followers, were the Number sufficient, would form a distinct Swarm. As it is not, they all go into the same Hive. But all, except one, are soon destroyed. The Reason is, the working Bees of an Hive have enough to do to prepare Cells, for lodging the Eggs of one Female, and it would be impossible for them, to prepare twice or thrice that Number.

Sometimes in two Parts of a Swarm, there are more than two Female Bees. In this Case too, as soon as they

they are lodged in the Hive, all are killed but one. Nature designs but one Female for each Swarm. But as many Things may destroy the Egg or Worm of this single Female, it was needful, that Provision should be made for Accidents. So that there are often twenty Females which live to Maturity with the Bees of one Swarm. But one only is then spared, whether they go out with the Swarm, or remain within.

As soon as the Swarm is gone out, the first Work of the remaining Bees, is to destroy the young Females. These are all immediately killed and carried out of the Hive: and it is common, the Morning after the going out of a Swarm, to see six, eight or more Female Bees, lying dead at some Distance from the Hive. What determines the Bees in favour of One, is her having Eggs ready to be hatched. Accordingly if new made Cells be examined, she will be found the very next Day, to have laid Eggs in many, if not all. Whereas if the Bodies of the rejected Females be examined, there will be found either no Eggs at all, or Eggs so extremely minute, that it must have been a long Time before any could have been laid.

It is not at all Times however, that the Bees are thus cruel to the supernumerary Females; but only at the Time when they are newly established in their Habitation, and in Want of all Things. At other Times they are as kind to strange Females as to their own. Mr. Reaumur tried the Experiment, by putting a strange Female into an Hive, where the Combs were perfect, and filled with Honey. And the Bees shewed the same Respect to her, as to their proper Sovereign.

The Wax is furnished by the *Farina* or *Meal* of Flowers; the Honey, by certain Vessels, near the Basis of the Flower-leaves, which continually secrete a sweet Juice. From these the Bee sucks either Honey, or a Juice of such a Nature as will produce Honey, under her Management.

The common Food of the Bee is the *Farina* of Flowers: A great Part of which after it has served them for Nourishment, is thrown out at their Mouths in
Form

Form of Wax. The Honey deposited in their waxen Cells, is for Food when they cannot go Abroad to search for other Food.

The Bee that comes loaded to any Cell, soon discharges his Honey into it. No sooner is he gone, than another comes, and so on, till the whole Cell is filled. But that which lies uppermost is always of a different Appearance from the rest of the Honey. It is a Kind of Cream, which both keeps the Honey moist, and prevents its running out by Accident.

This Crust or Cream was not, as one would think, voided last, but was gathering from the first. For the Bee which comes loaded to the Cell, does not at once discharge his Honey, but entering into it as deep as may be, thrusts out his Fore-legs, and pierces an Hole thro' the Crust. Keeping this open with his Feet, he disgorges the Honey in large Drops from his Mouth. He then closes the Hole, and this is regularly done by every Bee that contributes to the common Store.

But every Bee that comes loaded to the Hive, does not deposit his Honey in the Cell. They often dispose of it by the Way. Instead of going to any Cell, they often go to those that are at Work and call them to feed upon the Honey they have brought, that they may not be obliged to intermit their Work, on the Account of Hunger. These feed on the Store of the friendly Bee, by putting their Trunk into her Mouth, exactly in the same Manner as they do, into the Bottom of Flowers.

Some Cells in every Hive contain Honey for immediate Consumption, as in Case of bad Weather. And these are always open at the Top. Others contain their Provision for the Winter. These are all closed down with a strong Lid, not easily to be removed. Such is the Wisdom which the Great Author of Nature has imparted to some of the most inconsiderable of his Creatures.



General Observations and Reflections.

1. **A**S to the *Number* of Animals, the Species of *Beasts*, including also *Serpents*, are not very numerous. Such as are certainly known and clearly described, are not above an hundred and fifty. And yet probably not many that are of any considerable Bigness, have escaped the Notice of the Curious.

The Species of *Birds*, known and described are near five Hundred, and the Species of *Fishes*, secluding Shell-fish, as many; But if the *Shell-fish* are taken in, above six Times the Number. How many of each Genus remain undiscovered, we cannot very nearly conjecture. But we may suppose, the whole Sum of Beasts and Birds to exceed by a third Part, and Fishes by one half, those that are known.

The *Insects*, taking in the Exsanguious, both terrestrial and aquatic, may for Number vie even with Plants themselves. The Exsanguious alone, by what Dr. Lister has observed and delineated, we may conjecture cannot be less (if not many more) than three thousand Species. Indeed this Computation seems to be much too low: for if there are a thousand Species in this Island and the Sea near it; and if the same Proportion hold between the *Insects* native of *England*, and those of the rest of the World (about a Tenth:) The Species of *Insects* on the whole Globe, will amount to ten Thousand.

Now if the Number of Creatures even in this lower World, be so exceeding great; how great, how immense must be the Power and Wisdom of Him that formed them all! For as it argues far more Skill in an Artificer, to be able to frame both Clocks and Watches and Pumps and many other Sorts of Machines,

chines, than he could display in making but one of those Sorts of Engines: So the Almighty declares more of his Wisdom, in forming such a Multitude of different Sorts of Creatures, and all with admirable and unreprouable Art, than if he had created but a few.

2. Again. The same Superiority of Knowledge would be displayed, by contriving Engines for the same Purposes after different Fashions, as the moving Clocks or other Engines by Springs instead of Weights: And the infinitely wise Creator, has shewn by many Instances, that he is not confined to one only Instrument, for the working one Effect, but can perform the same Thing by divers Means. So tho' most flying Creatures have Feathers, yet hath he enabled several to fly without them, as the Bat, one Sort of Lizard, two Sorts of Fishes, and numberless Sorts of Insects. In like Manner, altho' the Air-bladder in Fishes seem necessary for Swimming: Yet are many so formed as to swim without it, as first, the *Cartilaginous* Kind, which nevertheless do ascend and descend at Pleasure, altho' by what Means we cannot tell. Secondly, The *Cetaceous* Kind: The Air which they receive into their Lungs, in some Measure answering the same End.

Yet again. Tho' God has tempered the Blood and Bodies of most Fishes to their cold Element, yet to shew he can preserve a Creature as hot as Beasts themselves in the coldest Water, he has placed Variety of these *Cetaceous* Fishes in the Northernmost Seas. And the copious Fat wherewith their Body is inclosed, by reflecting the internal Heat, and keeping off the external Cold, keeps them warm, even in the Neighbourhood of the Pole.

Another Proof that God can by different Means produce the same Effect, is the various Ways of extracting the Nutritious Juice out of the Aliment in various Creatures.

In *Man* and *Beasts* the Food, first chewed, is received into the Stomach, where it is concocted and reduced into Chyle, and so evacuated into the Intestines, where being mixt with the *Choler* and *Pancreatic* Juice,

it

it is farther subtilized, and rendered so fluid, that its finer Parts easily enter the Mouth of the Lacteal Veins.

In *Birds* there is no chewing: But in such as are not Carnivorous, it is immediately swallowed into the Crop, or Anti-stomach (which is observed in many, especially piscivorous Birds) where it is moistened by some proper Juice, and then transferred to the Gizzard, by the working of whose Muscles, assisted by small Pebbles, which they swallow for that Purpose, it is ground small, and so transmitted to the Intestines.

In oviparous *Reptiles*, and all Kind of *Serpents*, there is neither Chewing nor Commination in the Stomach, but as they swallow Animals whole, so they void the Skins unbroken, having extracted the nutritious Juices. Here, by the by, we may observe the wonderful Dilatability of the Throats and Gullets of Serpents. Two entire adult Mice have been taken out of the Stomach of an Adder, whose Neck was no bigger than one's little Finger.

Fishes, which neither chew, nor grind their Meat, do, by Means of a corrosive Juice in their Stomach, reduce Skin, Bones and all into Chyle. And yet this Juice shews no Acidity to the Taste. But how mild so ever it tastes, it corrodes all animal Substances, as *Aqua-fortis* does Iron.

3. Several eminent Men have been of Opinion, that all Brutes are mere Machines. This may be agreeable enough to the Pride of Man; but it is not agreeable to daily Observation. Do we not continually observe in the Brutes which are round about us, a Degree of Reason? Many of their Actions cannot be accounted for without it: As that commonly noted of Dogs, that running before their Masters, they will stop at a Parting of the Road, till they see which Way their Masters take. And when they have gotten what they fear will be taken from them, they run away and hide it. Nay, what account can be given, why a Dog being to leap on a Table, which he sees he cannot reach at once, if a Stool or Chair stands near it,

first mounts that, and thence proceeds to the Table ? If he were mere Clock-work, and his Motion caused by a material Spring, that Spring being once set to work, would carry the Machine in a right Lie, toward the Object that put it in Motion. —

Were it true, that Brutes were mere Machines, they could have no Perception of Pleasure or Pain. But how contrary is this, to the doleful Significations they give, when beaten or tormented ? How contrary to the common Sense of Mankind ? For do we not all naturally pity them, apprehending them to feel Pain just as we do ? Whereas no Man is troubled to see a Plant torn, or cut, or mangled how you please. And how contrary to Scripture ? *A righteous Man regardeth the Life of his Beast : But the tender Mercies of the Wicked are cruel.* Prov. xii. 10. The former Clause is usually rendered, *A good Man is merciful to his Beast.* And this is the true rendering, as appears by the opposite Clause, *That the Wicked is cruel.* Cruelty then may be exercised toward Beast. But this could not be, were they mere Machines.

4. The *Natural Instinct* of all Creatures, and the special Provision made for some of the most helpless, do in a particular Manner demonstrate the great Creator's Care.

First, What an admirable Principle is the Natural affection of all Creatures toward their Young ! By means of this, with what Care do they nurse them up, thinking no Pains too great to be taken for them, no Danger too great to be ventured upon, for their Guard, and Security ! How will they caress them with their affectionate Notes, put Food into their Mouths, suckle them, cherish and keep them warm, teach them to pick, and eat, and gather Food for themselves : And in a Word, perform the whole Part of so many Nurses, deputed by the sovereign Lord of the World, to help such young and helpless Creatures, till they are able to shift for themselves.

Other Animals, Insects in particular, whose Offspring is too numerous for the Parent's Provision, are so generated, as to need none of their Care. For they arrive

arrive immediately at their perfect State, and so are able to shift for themselves. Yet thus far the parental Instinct (equal to the most rational Fore-sight) extends, that they do not drop their Eggs any where, but in commodious Places, suitable to their Species. And some include in their Nests, sufficient and agreeable Food, to serve their Young till they come to Maturity.

And for the Young themselves. As the Parent is not able to carry them about, to cloath them and dandle them, as Man doth : How admirably is it contrived, that they can soon walk about, and begin to shift for themselves ! How naturally do they hunt for their Teat, suck, pick and take in their proper Food !

On the other Hand, the Young of Man, (as their Parent's Reason is sufficient, to help, to nurse, feed and cloath them) are born utterly helpless, and are more absolutely than any Creature, cast upon their Parent's Care.

Secondly, What admirable Provision is made for some of the most helpless Creatures, at a Time when they must otherwise utterly perish ! The Winter is an improper Season to afford Food to Insects and many other Animals. When the Fields, Trees and Plants are naked, and the Air is chilled with Frost ; what would become of such Animals, whose tender Bodies are impatient of Cold : And who are nourished only by the Produce of the Spring or Summer ? To prevent their total Destruction, the wise Preserver of the World has so ordered, that in the first Place, those which are impatient of Cold, should have such a peculiar Structure of Body, as during that Season, not to suffer any Waste, nor consequently need any Recruit. Hence many Sorts of Birds, and almost all Insects, pass the whole Winter without any Food. And most of them without any Respiration. It seems all Motion of the Animal Juices is extinct. For tho' cut in Pieces they do not awake, nor does any Fluid ooze out at the Wound. This Sleep therefore is little less than Death,

and their Waking, than a Resurrection: When the returning Sun revives them and their Food together.

The next Provision is for such Creatures as can bear the Cold, but would want Food. This is provided against in some, by a long Patience of Hunger, in others by their wonderful Instinct, in laying up Food before-hand, against the approaching Winter. By some of these, their little Treasuries are at the proper Season well stocked with Provisions. Yea, whole Fields are here and there bespread, with the Fruits of the neighbouring Trees, laid carefully up in the Earth and covered safe, by provident little Animals.

5. And what a prodigious Act is it of the Creator's Indulgence, to the poor, shistless Irrationals, that they are already furnished with such *Cloathing*, as is proper to their Place and Business! With Hair, with Feathers, with Shells, or with firm Armature, all nicely accommodated, as well to the Element wherein they live, as to their several Occasions there. To *Beasts* Hair is a commodious Cloathing; which together with the apt Texture of their Skin, fits them in all Weathers, to lie on the Ground, and to do their Service to Man. The thick and warm Fleeces of others, are a good Defence against the Cold and Wet, and also a soft Bed: Yea, and to many a comfortable Covering for their tender Young.

And as Hair is a commodious Dress for Beasts, so are Feathers for *Birds*. They are not only a good Guard against Wet and Cold, but nicely placed every where on the Body, to give them an easy Passage thro' the Air, and to waft them thro' that thin Medium. How curious is their Texture for Lightness, and with all close and firm for Strength! And where it is necessary they should be filled, what a light, medullary Substance are they filled with? So that even the strongest Parts, far from being a Load to the Body, rather help to make it light and buoyant. And how curiously are the Vanes of the Feathers wrought, with capillary Filaments, neatly interwoven together, whereby they are sufficiently close and strong, both to guard the Body against the Injuries of the Weather,

and

and to empower the Wings, like so many Sails, to make strong Impulses on the Air in their Flight.

No less curious is the Cloathing of *Reptiles*. How well adapted are the Rings of some, and the Contortions of the Skin of others, not only to fence the Body sufficiently, but to enable them to creep, to perforate the Earth, and to perform all the Offices of their State, better than any other Covering?

Observe, for Instance, the Tegument of the *Earth-worms*, made in the completest Manner, for making their Passage thro' the Earth, wherever their Occasions lead them. Their Body is made throughout of small Rings, which have a curious Apparatus of Muscles, that enable them with great Strength to dilate, extend or contract their whole Body. Each Ring is likewise armed with stiff, sharp Prickles, which they can open at Pleasure, or shut close to their Body. Lastly, under their Skin there is a slimy Juice, which they emit, as Occasion requires, to lubricate the Body, and facilitate their Passage into the Earth. By all these Means they are enabled, with Ease and Speed, to work themselves into the Earth, which they could not do, were they covered with Hair, Feathers, Scales, or such Cloathing as any of the other Creatures.

How wisely likewise are the Inhabitants of the Waters clothed! The Shells of some *Fishes*, are a strong Guard to their tender Bodies, and consistent enough with their slow Motion: While the Scales and Fins of others afford them an easy and swift Passage thro' the Waters.

6. Admirable likewise is the Sagacity of Brute-Animals, in the Conveniency and Method of their *Habitations*. Their architectonic Skill herein, exceeds all the Skill of Man. With what inimitable Art do some of these poor, untaught Creatures, lay a Parcel of rude, ugly Sticks or Straws together! With what Curiosity do they line them within, yea, wind and place, every Hair, Feather or Lock of Wool, to guard and keep warm the tender Bodies, both of themselves and their Young? And with what Art do they thatch over and coat their Nests without, to deceive the Eye

of

of the Spectators, as well as to guard and fence them against the Injuries of the Weather?

Even *Insects*, those little, weak, tender Creatures, what Artists are they in building their Habitations? How does the Bee gather its Comb from various Flowers, the Wasp from solid Timber? " With what Accuracy do other Insects perforate, the Earth, Wood, yea, Stone itself? Farther yet, with what Care and Neatness do most of them line their Houses within, and seal them up and fence them without? How artificially do others fold up the Leaves of Trees; others glue light Bodies together, and make floating Houses, to transport themselves to and fro, as their various Occasions require!

7. Another Instance of the Wisdom of him that made and governs the World we have in the *Balance of Creatures*. The whole Surface of the terraqueous Globe, can afford Room and Support, to no more than a determinate Number of all Sorts of Creatures. And if they should increase to double or treble the Number, they must starve or devour one another. To keep the Balance even, the great Author of Nature has determined the Life of all Creatures to such a Length, and their Increase to such a Number, proportioned to their Use in the World. The Life indeed of some hurtful Creatures is long; of the Lion in particular. But then their Increase is exceeding small: And by that Means they do not over-Rock the World. On the other Hand, where the Increase is great, the Lives of those Creatures are generally short. And beside this, they are of great Use to Man, either for Food, or on other Occasions. This indeed should be particularly observed, as a signal Instance of Divine Providence, that useful Creatures are produced in great Plenty: others in smaller

" Wasps at their first Coming frequent Posts, Boards and other dry Wood that is found, but never any that is rotten. This they scrape and gnaw, and what they gnaw off, they keep close together between their Chin and Fore-legs, until they have gotten enough for a Burden. They then carry it away in their Mouths, to make their Combs with,

smaller Numbers. The prodigious Increase of Insects, both in and out of the Waters may exemplify the former Observation. For innumerable Creatures feed upon them, and would perish, were it not for this Supply. And the latter is confirmed by what many have remarked; that Creatures of little Use, or by their Voraciousness, pernicious, either seldom bring forth, or have but one or two at a Birth.

8. How remarkable is the *Destruction* and *Reparation* of the whole *Animal* Creation? The Surface of the Earth is the inexhaustible Source whence both Man and Beast derive their Subsistence. Whatever lives, lives on what vegetates, and Vegetables in their turn, live, on whatever has lived or vegetated. It is impossible for any Thing to live, without destroying something else. It is thus only that Animals can subsist themselves, and propagate their Species.

God in creating the first Individual of each Species, Animal or Vegetable, not only gave a Form to the Dust of the Earth, but a Principle of Life, inclosing in each, a greater or smaller Quantity of Organical Particles, indestructible, and common to all organized Beings. These pass from Body to Body, supporting the Life, and ministering to the Nutrition and Growth of each. And when any Body is reduced to Ashes, these organical Particles, on which Death hath no Power, survive and pass into other Beings, bringing with them Nourishment and Life. Thus every Production, every Renovation, every Increase by Generation or Nutrition, suppose a preceding Destruction, a Conversion of Substance, an Accession of these organical Particles which ever subsisting in an equal Number, render Nature always equally full of Life.

The total Quantity of Life in the Universe is therefore perpetually the same. And whatever Death seems to destroy, it destroys no Part of that primitive Life, which is diffused thro' all organized Beings. Instead of injuring Nature, it only causes it to shine with the greater Lustre. If Death is permitted to cut down Individuals, it is only, in order to make of the Universe, by the Reproduction of Beings, a Theatre ever crowded, a Spectacle ever new. But it is never

ver permitted to destroy the most inconsiderable Species.

That Beings may succeed each other, it is necessary that there be a Destruction among them: Yet like a provident Mother, Nature in the midst of her inexhaustible Abundance, has prevented any Waste, by the few Species of carnivorous Animals, and the few Individuals of each Species; multiplying at the same Time both the Species and Individuals of those that feed on Herbage. In Vegetables she seems to be profuse, both with Regard to the Number and Fertility of the Species.

In the Sea indeed all the Species are carnivorous. But tho' they are perpetually preying upon, they never destroy each other, because their Fruitfulness is equal to their Depredations.

" Thus thro' successive Ages stands

Firm fixt thy providential Care!

Pleased with the Works of thy own Hands

Thou dost the Wastes of Time repair."

9. I add a few more Reflections on the World in general. The same wise Being, who was pleased to make Man, prepared for him also an Habitation, so advantageously placed, that the Heavens and the rest of the Universe might serve it both as an Ornament and a Covering. He constructed likewise the Air which Man was to breathe, and the Fire which was to sustain his Life. He prepared also Metals, Salts and all terrestrial Elements to renew and maintain throughout all Ages, whatever might be on any Account necessary for the Inhabitants of the Earth.

The same Divine Ruler is manifest in all the Objects that compose the Universe. It is he that caused the Dry-land to appear, above the Surface of the Ocean, that gauged the Capacity of that amazing Reservoir, and proportioned it to the Fluid it contains. He collects the rising Vapours and causes them to distill in gentle Showers. At his Command the Sun darts his invivcning Rays, and the Winds scatter the

noxious

noxious Effluvia, which if they were collected together might destroy the human Race.

He formed those Hills and lofty Mountains which receive and retain the Water within their Bowels, in order to distribute it with Economy to the Inhabitants of the Plains, and to give it such an Impulse, as might enable it to overcome the Unevenness of the Lands, and convey it to the remotest Habitations.

He spread under the Plains Beds of Clay or compact Earths, there to stop the Waters, which after a great Rain, make their Way, thro' innumerable little Passages. These Sheets of Water frequently remain in a Level with the neighbouring Rivers, and fill our Wells with their Redundancy, or as those subside, flow into them again.

He proportioned the Variety of Plants in each Country, to the Exigences of the Inhabitants, and adapted the Variety of the Soils, to the Nature of those Plants.

He endued numerous Animals with mild Dispositions, to make them the Domestic of Man: And taught the other Animals to govern themselves, with an Aversion to Dependence, in order to continue their Species without loading Man with too many Cares.

If we more nearly survey the Animal and Vegetable World, we find all Animals and Plants, have a certain and determined Form, which is invariably the same. So that if a Monster ever appear, it cannot propagate its Kind, and introduce a new Species into the Universe. Great indeed is the Variety of organized Bodies. But their Number is limited. Nor is it possible to add a new Genus either of Plants or Animals, to those of which God has created the Germina, and determined the Form.

The same Almighty Power, has created a precise Number of simple Elements, essentially different from each other, and invariably the same. By these he varies the Scene of the Universe, and at the same Time prevents its Destruction, by the very Immutability of the Nature and Number of these Elements. So that the World is for ever changed, and yet eternally the same.

Yet

Yet if we would *account* for the Origin of these Elements, we are involved in endless Uncertainty. We can only say, he who has appointed their different Uses in all Ages, has rendered those Uses infallible, by the Impossibility of either destroying or increasing them.

Herein we read the Characters of his Power, which is invariably obeyed; of his Wisdom, which has abundantly provided for every Thing, and of his tender Kindness toward Man for whom he has provided Services equally various and infallible. It is an additional Proof of his continual Care of his Creatures, that tho' every Thing be composed of simple Elements, all placed within our Reach, yet no Power is able to destroy the least Particle of them. Nothing but the same Cause which was able to give them Birth, can annihilate them, or change their Nature. In Truth, the Design and Will of the Creator, is the only physical Cause of the general Economy of the World: The only physical Cause of every organized Body, every Germen that flourishes in it; the only physical Cause of every Minute, elementary Particle, which enters into the Composition of all.

We must not then expect, ever to have clear and full Conceptions of Effects, Natures and Causes. For where is the Thing which we can fully conceive? We can no more comprehend either what Body in general is, or any particular Body, suppose a Mass of Clay, or a Ball of Lead, than what a Spirit, or what God is.

If we turn our Eyes to the minutest Parts of animal Life, we shall be lost in Astonishment! And tho' every Thing is alike easy to the Almighty, yet to us it is Matter of the highest Wonder, that in those Specks of Life, we find a greater Number of Members to be put in Motion, more Wheels and Pullies to be kept going, and a greater Variety of Machinery, more Elegance and Workmanship (so to speak) in the Composition, more Beauty and Ornament in the finishing, than are seen in the enormous Bulk of the Crocodile, the Elephant, or the Whale: Yea, they seem to be the Effects of an Art, as much
more

more exquisite, as the Movements of a Watch are, than those of a Coach or Waggon.

Hence we learn, That an Atom to God is as a World, and a World but as an Atom: Just as to Him, one Day is as a thousand Years; and a thousand Years but as one Day. Every Species likewise of these Animalcula may serve to correct our Pride, and shew how inadequate our Notions are, to the real Nature of Things. How extremely little can we possibly know, either of the largest or smallest Part of the Creation? We are furnished with Organs capable of discerning, to a certain Degree of great or little only. All beyond is as far beyond the Reach of our Conceptions, as if it had never existed.

Proofs of a wise, a good and powerful Being are indeed deducible from every Thing around us: But the extremely Great and the extremely Small, seem to furnish us with those that are most convincing. And perhaps, if duly considered, the Fabrick of a World, and the Fabric of a Mite, may be found equally striking and conclusive.

Glasses discover to us numberless Kinds of living Creatures, quite indiscernible to the naked Eye. And how many thousand Kinds may there be, gradually decreasing in Size, which we cannot see by any Help whatever? Yet to all these we must believe God has not only appointed the most wise Means for Preservation and Propagation, but has adorned them with Beauty equal at least to any Thing our Eyes have seen.

In short, the World around us is the mighty Volume wherein God hath declared himself. Human Languages and Characters are different in different Nations. And those of one Nation are not understood by the rest. But the Book of Nature is written in an universal Character, which every Man may read in his own Language. It consists not of Words, but Things, which picture out the Divine Perfections. The Firmament every where expanded, with all its starry Host, declares the Immensity and Magnificence, the Power and Wisdom of its Creator. Thunder, Lightning, Storms, Earthquakes and Vulcanos, shew the Terror of his Wrath. Seasonable Rains, Sun-shine and Harvest, denote his Bounty and

Goodness, and demonstrate how he opens his Hand, and fills all Things living with Plenteousness. The constantly succeeding Generations of Plants and Animals, imply the Eternity of their first Cause. Life subsisting in Millions of different Forms, shews the vast Diffusion of his animating Power, and Death the infinite Disproportion between him and every living Thing.

Even the Actions of Animals are an eloquent and pathetic Language. Those that want the Help of Man have a Thousand engaging Ways, which, like the Voice of God speaking to his Heart, command him to preserve and cherish them. In the meantime the Motions or Looks of those which might do him Harm, strike him with terror, and warn him, either to fly from, or arm himself against them. Thus it is, that every Part of Nature directs us to Nature's God.

10. The Reader will easily excuse my concluding this Chapter also, with an Extract from Mr. *Hervey*.

"In all the animal World, we find no Tribe, no Individual neglected by its Creator. Even the ignoble Creatures are most wisely circumstanced and most liberally accommodated.

They all generate in that particular Season, which supplies them with a Stock of Provisions, sufficient not only for themselves, but for their increasing Families. The Sheep yearn, when there is Herbage to fill their Udders, and create Milk for their Lambs. The Birds hatch their Young, when new-born Insects swarm on every Side. So that the Caterer, whether it be the Male or Female Parent, needs only to alight on the Ground, or make a little Excursion into the Air, and find a Feast ready dress'd for the Mouths at Home.

Their Love to their Offspring, while they are helpless, is invincibly strong: Whereas the Moment they are able to shift for themselves, it vanishes as tho' it had never been. The Hen that marches at the Head of her little Brood, would fly at a Mastiff in their Defence. Yet within a few Weeks, she leaves them to the wide World, and does not even know them any more.

Hervey's Works, vol. 1. p. 101. 11

If the God of *Israel* inspired *Bezaleel* and *Aholiah* with *Wisdom* and *Knowledge* in all Manner of *Workmanship*, the God of Nature has not been wanting, in his Instructions to the Fowls of the Air. The Skill with which they erect their Houses, and adjust their Apartments is inimitable. The Caution with which they hide their Abodes from the searching Eye or intruding Hand is admirable. No General, tho' fruitful in Expedients, could plan a more artful Concealment. No Architect, with his Rule and Line, could build so commodious a Lodgment. Give the most celebrated Artificer the same Materials, which these weak and unexperienced Creatures use. Let a *Jones* or a *Demoivre* have only some rude Stones or ugly Sticks, a few Bits of Dirt or Scraps of Hair, a Lock of Wool, or a coarse Sprig of Moss: And what Works could they produce?

We extol the Commander, who knows how to take Advantage of the Ground; who by every Circumstance embarrasses the Forces of his Enemy, and advances the Success of his own. Does not this Praise belong to the feathered Leaders? Who fix their pensile Camp, on the dangerous Branches that wave aloft in the Air, or dance over the Stream? By this Means the vernal Gales rock their Cradle, and the murmuring Waters lull their Young, while both concur to terrify their Enemies, and keep them at a Distance. Some hide their little Household from View, amidst the Shelter of intangled Furze. Others remove it from Discovery, in the Center of a thorny Thicket. And by one Stratagem or another they are generally as secure, as if they intrenched themselves in the Earth.

If the *Swan* has large, sweeping Wings and a copious Stock of Feathers, to spread over his callow Young, the *Wren* makes up by Contrivance, what is wanting in her Bulk. Small as she is, she will be obliged to nurse up, a very numerous Issue. Therefore with surprizing Judgment she designs, and with wonderful Diligence finishes her Nest. It is a neat Oval, bottomed and vaulted over with a regular Concave: Within made soft with Down, without thatched

thatched with Moss, only a small Aperture left for her Entrance. By this Means the invivifying Heat of her Body is greatly increased during the Time of Incubation. And her Young no sooner burst the Shell, than they find themselves screened from the Annoyance of the Weather, and comfortably reposed, till they gather Strength, in the Warmth of a Bagnio.

Perhaps we have been accustomed to look upon *Insects*, as so many rude Scraps of Creation. But if we examine them with Attention, they will appear some of the most polished Pieces of Divine Workmanship. Many of them are decked with the richest Finery. Their Eyes are an Assemblage of Microscopes: The common Fly, for Instance, who surrounded with Enemies, has neither Strength to resist, nor a Place of Retreat to secure herself. For this Reason she has need to be very vigilant, and always upon her Guard. But her Head is so fixt, that it cannot turn to see what passes, either behind or around her. Providence therefore has given her, not barely a Retinue, but more than a Legion of Eyes: Inasmuch that a single Fly is supposed to be Mistress of no less than Eight Thousand. By the Help of this truly amazing Apparatus, she sees on every Side, with the utmost Ease and Speed, tho' without any Motion of the Eye, or Flexion of the Neck.

The *Dress* of *Insects* is a Vesture of resplendent Colours, set with an Arrangement of the brightest Gems. Their *Wings* are the finest Expansion imaginable, compared to which, Lawn is coarse as Sackcloth. The *Cases*, which inclose their Wings glitter with the finest Varnish, are scooped into ornamental Flutings, are studded with radiant Spots, or pinked with elegant Holes. Not one but is endued with Weapons to seize their Prey, and Dexterity to escape their Foe, to dispatch their Business of their Station, and enjoy the Pleasures of their Condition.

What if the Elephant is distinguished by his huge *Proboscis*? The Use of this is answered in these his meaner Relations, by their curious *Feelers*, remarkable, if not for their enormous Size, yet for their ready

ready Flexion and quick Sensibility. By these they explore their Way in the darkest Road: By these they discover and avoid, whatever might defile their neat Apparel, or endanger their tender Lives.

Every one admires the majestic Horse. With how rapid a Career does he bound along the Plain? Yet the *Grass-hopper* springs forward with a Bound abundantly more impetuous. The *Ant* too, in Proportion to his Size, excells him both in Swiftnes and Strength: And will climb Precipices, which the most couragious Courser dares not attempt to scale. If the *Snail* moves more slowly, she has however no need to go the same Way twice over: Because whenever she departs, wherever she removes, she is always at home.

The *Eagle* it is true, is privileged with Pinions that out-strip the Wind. Yet neither is that poor outcast, the groveling *Mole*, disregarded by divine Providence. Because she is to dig her Cell in the Earth, her Paws serve for a Pickax and Spade. Her Eye is sunk deep into its Socket, that it may not be hurt by her rugged Situation. And as it needs very little Light, she has no Reason to complain of her dark Abode. So that her subterranean Habitation, which some might call a Dungeon, yields her all the Safety of a fortified Castle, and all the Delights of a decorated Grot.

Even the *Spider*, tho' abhorred by Man, is the Care of all-sustaining Heaven. She is to support herself by trepanning the wandring Fly. Suitably to her Employ, she has Bags of glutinous Moisture. From this she spins a clammy Thread and weaves it into a tenacious Net. This she spreads in the most opportune Place. But knowing her Appearance would deter him from approaching, she then retires out of Sight. Yet she constantly keeps within Distance; so as to receive immediate Intelligence when any Thing falls into her Toils, ready to spring out in the very Instant. And it is observable, when Winter chills the Air, and no more Insects rove thro' it, knowing her Labour would be in vain, she leaves her Stand, and discontinues her Work.

I must not forget the Inhabitants of the Hive. The *Bee* subsist as a regular Community. And their indul-

gent Creator has given them all Implements necessary, either for building their Combs, or composing their Honey. They have each a portable Vessel, in which they bring home their collected Sweets: And they have the most commodious Store-houses, wherein they deposit them. They readily distinguish every Plant, which affords Materials for their Business: And are complete Practitioners in the Arts of Separation and Refinement. They are aware that the vernal Bloom and Summer Sun continue but for a Season. Therefore they improve to the utmost every shining Hour, and lay up a Stock sufficient to supply the whole State, till their flowry Harvest returns.

If the Master of this lower Creation, is ennobled with the Powers of Reason, the meanest Classes of sensitive Beings, are endued with the Faculty of *Instinct*: A Sagacity, which is neither derived from Observation, nor waits the Finishings of Experience: Which without a Tutor teaches them all necessary Skill, and enables them without a Pattern, to perform every needful Operation. And what is more remarkable, it never misleads them, either into erroneous Principles, or pernicious Practices: Nor never fails them in the most nice and difficult of their Undertakings.

Let us step into another Element, and just visit the watry World. There is not one among the innumerable Myriads, that swim the boundless Ocean, but is watched over by the sovereign Eye, and supported by his almighty Hand. He has condescended even to beautify them. He has given the most exact Proportion to their Shape, the gayest Colours to their Skin, and a polished Surface to their Scales. The Eyes of some are surrounded with a scarlet Circle; the Backs of others, diversified with crimson Stains. View them when they glance along the Stream, or when they are fresh from their native Brine, the Silver is not more bright, nor the Rainbow more glowing than their vivid, glossy Hues.

But as they have neither Hands nor Feet, how can they help themselves, or escape their Enemies? By the beneficial, as well as ornamental Furniture of *Fins*, These when expanded, like Masts above and Ballast below

low, poise their floating Bodies, and keep them steddily upright. They are likewise greatly assisted by the Flexibility and vigorous Activity of their Tails. With which they shoot thro' the Paths of the Sea, swifter than a Vessel with all its Sails. But we are lost in Wonder at the exquisite Contrivance and delicate Formation of their *Gills* : By which they are accommodated, even in that dense Medium, with the Benefits of Respiration ! A Piece of Mechanism this, indulged to the meanest of the Fry : Yet infinitely surpassing in the Fineness of its Structure and Operation, whatever is curious in the Works of Art, or commodious in the Palaces of Princes.





Part the Third.

Of Plants and Fossils.

CHAP. I.

OF Plants.

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|-------------------------------------|-------------------------------------|
| 1. <i>What we mean by Plants :</i> | 10. <i>The Motion of the Nutri-</i> |
| 2. <i>Their liquid Parts :</i> | <i>tive Juice :</i> |
| 3. <i>Their solid Parts :</i> | 11. <i>Of the Agreement between</i> |
| 4. <i>Of the Bark :</i> | <i>Plants and Animals :</i> |
| 5. <i>The Wood :</i> | 12. <i>Of the Generation of</i> |
| 6. <i>The Pith :</i> | <i>Plants :</i> |
| 7. <i>The Root and Branches :</i> | 13. <i>Their Flowers :</i> |
| 8. <i>Of the Leaves :</i> | 14. <i>Their Seeds :</i> |
| 9. <i>The Nutrition of Plants :</i> | 15. <i>Their Fruits.</i> |

1. **B**Y *Plants* we mean organized Bodies, destitute of Sense and Motion, fixt in the Earth, and drawing their Nourishment from it by their Roots. Touching these, we may consider, first, the Structure of their Parts, and then their Nutrition and their Generation.

2. The *Parts* of which they are composed are either *liquid* or *solid*. The *Liquid* are usually divided into *Juices* and *Tears*. The *Juice* is to the Plant what *Blood* is

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to an Animal, and is various in the various Kinds of Plants. Tears are Liquors which are emitted from them, whether they sweat out of them naturally ; or are drawn out of them, either by Art, or by the Heat of the Sun. Some of these remain liquid ; others grow by Degrees into a firm Consistence.

3. Plants consist of three *diffimilar*, *solid* Parts, the *Root*, the *Trunk*, and the *Branches*. In each of these we may observe three *similar* Parts, the *Bark*, the *Wood* and the *Pith*.

4. To begin with the Trunk. Here we may first observe the *Bark* ; whose Surface consists of little Bladders, which surround the Trunk like a Ring. These, which are commonly filled with some Kind of Juice, being removed, there occur various Ranks of woody Fibres, curiously wrought in a Kind of Net-work, one Row above another. The Intervals also between those Fibres, are all filled with little Vessels. The Use of the Bark seems to be, not on'y like Skin, to cover the Wood and Pith, but also to concoct the Nutritive Juice, and forward the Growth of the Plant. And as to the Nutrition of the Bark, it is probable the Juice ascends from the Root, thro' the Fibres, and is sustained by the Unevenness therein, 'till it is lodged in the Vessels. In these the new Juice being mixt, with that they contained before, is fermented and rarefied to such a Degree, as is needful for its Nourishment.

It has been a common Opinion, that Trees only live by the Ascent of the Sap in the Bark, or between the Bark and the Wood: But this evidently appears to be a vulgar Error, from the Instance of a large, old Elm, in *Magdalene-College Grove* at *Oxford*, which was quite disbarked all round, at most Places two Feet, at some, four Feet from the Ground. Notwithstanding this, it grew and flourished many Years, as well as any Tree in the Grove. What is more, it was likewise without all Pith, being ho'low within as a Drum. Add to this, that the Plane and Cork-trees, divest themselves every Year, of all their old Bark, (as Snakes do of their Skins) and acquire a new one. Now during the Change from one to the other, it is clear they are not nourished by
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the Bark. Therefore there must be other Vessels, beside those of the Bark, capable of conveying the Sap. It is probable, the Bark may ordinarily do this: But that when the ordinary Conveyance fails, some of the woody Parts (which were all Sap-vessels once) resume their antient Office: So far, at least, as to keep the Tree alive, tho' not to increase its Bulk. Perhaps this is the Use of the Sap-vessels in the Wood, different from that of those in the Bark. These are designed for the Continuation of a Tree, those in the Bark for its Augmentation.

Again. As Animals are furnished with a *Panniculus Adiposus*, usually replete with Fat, which invests and covers all the fleshy Parts, and screens them from external Cold: So Plants are incompart with a Bark, replete with fatty Juices, by Means whereof even the Winter Cold is kept off, and hindred from freezing the Juices in the Vessels. And those Sorts of Trees, whose Bark abounds with Oil, remain green all the Year round.

5. In the Wood likewise there are observed concave Fibres, woven as it were of various Vesicles, and stretching all the Length of the Wood, as do the Fibres of the Bark. These have intervals between them, in which are transverse Vesicles, reaching to the very Pith. There are other Fibres, which run obliquely, and are far larger, but not so numerous as the former. In some Trees there are also several Rows of Tubes, which emit a thick, milky Liquor.

6. The Pith is in the Middle of the Wood. It consists of various Rows of hollow Globules, covered with a fine Membrane. In some Trees it contains a peculiar Juice, which sometimes hardens, or grows black. In tender Shoots the Pith (which is frequently hexagonal) is not exactly in the Middle: But is nearer the Bark on the South-side, than on the North-side of the Plant. It is a constant Observation, that the Pith lessens as the Tree grows. Some have imagined it to be the Heart of the Plant: But this cannot be. For some Trees will flourish and bear Fruit, after the Pith is taken out. Besides this, there is in some Trees a Blea, a white and tender Substance, between the Bark and the Wood.

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7. The *Root* has nearly the same Vessels as the *Trunk*. Through it the Juice passes that nourishes the Plant. The *Roots* of some Plants are full of hollow Threads, which transmit Nourishment to the upper Parts. This in other Plants insinuates itself thro' the Pores that are in the *Bark* of the *Root*. The *Branches* of a Plant agree with the *Trunk*, in all the essential Parts of its Structure.

8. On the smallest Part of the *Branches* grow the *Leaves*; of these we may observe, 1. The *Fibres* of the *Leaf* stand not on the *Stalk* in an even Line, but always in an *angular* or *circular* Posture: And their vascular *Fibres* or *Threads*, are three, five or seven. The Reason of this Position is, for the more erect Growth, and for the greater Strength of the *Leaf*; as also for the Security of its *Sap*: 2. The accurate *Position* of these *Fibres*, so as often to take in the eighth Part of a Circle, as in *Mallows*; in some Plants a Tenth; but in most a Twelfth. 3. The Art in *folding* up the *Leaves* before their Eruption, is incomparable both for Elegance and Security. They take up the least Room their Form will bear; and are so conveniently couched, as to be capable of receiving Protection from other Parts, and of giving it to each other.

Leaves consist of *Fibres* continued from the *Trunk* of the *Tree*. They are cloathed with an extremely thin Pellicle which is covered with the finest Down. Their Skin or Coat is only that of the *Branches* extended, as Gold is by beating. In the Bud they are folded up, almost in the Manner of a Fan, sometimes in two, sometimes in several Plaits. But if they are too thick to plait commodiously in two, and to be ranged against each other, or if they are too small a Number, or their *Fibres* too delicate; instead of being plaited, they are rolled up, and form either a single Roll, or two Rolls, which begin at each Extremity of the *Leaf*, and meet in the Middle. There are also some Plants, as *Fern* in particular, which form three Rolls.

The chief Uses of *Leaves* seem to be, 1. To catch the Dew and Rain, and so convey more Nourishment to the Plant, than the *Root* alone could do: 2. To take in Air; (of which more hereafter :) And 3. To minister

to a Kind of Insensible Perspiration, by which Redundancies may be thrown off.

9. The *Nutrition* of Plants seems to be performed thus. As the Earth abounds with Particles of every Sort, those which suit each Plant, being dissolved by Moisture and agitated by Heat, enter the Root thro' its Threads or Pores, ascend thro' the woody Fibres, and being in the Vessels of the Plant mixt with its native Juice, and subtilized by Fermentation, insinuate themselves into all the Parts of it. Part of this nourishes the Plant and forms the Fruit; the Residue transpires. But as all Particles are not equally fit to enter the Pores of every Plant, neither can all be fermented into a Juice proper to nourish it; the Reason is plain, why every Plant will not flourish in every Soil.

But altho' Vegetables delight in peculiar Soils, they do not owe their Nourishment, to the Earth itself, but to Juices residing therein. Of this Mr. Boyle has given us plain Proof. He ordered his Gardener to dig up some Earth, to dry it in a Oven, to weigh it, and then plant therein some *Spanish Seeds*, (a kind of *Pumpkin*.) The Seeds when sown were watered with Rain or Spring-Water only. A Plant was produced in one Experiment, of near three Pounds; in another of above Fourteen. And yet the Earth when dried and weighed again, was not diminished at all in its Weight.

10. As to the *Motion* of the Nutritive Juice, some think it ascends by the Wood, and descends by the Bark. But it is not easy to shew, by what particular Tubes it either ascends or descends. Neither after all our Researches does it appear, what is the Principle of this Motion? Whether there be any such Thing as an Attractive Force in the Plant itself: Or whether it be performed on the mere Principles of Mechanism, by the Expansion of the Air contained in the Juice, which moves and propells the Particles of it into every Part of the Plant.

However that the Sap in Plants does circulate is made probable by an easy Experiment. On a Branch of a plain *Jessamine*, whose Stem spreads into two or three Branches, inoculate in Autumn, a Bud of the yellow striped

ed Jessamine. When the Tree shoots the next Summer, some of the Leaves will be striped with yellow, even on the Branches not inoculated. And by Degrees, the whole Tree will be striped, yea the very Wood of the young Branches.

It is probable the Circulation is performed thus. The Wood of Plants consists of fine, capillary Tubes, which run parallel with each other from the Root, and may be looked upon as *Arteries*. On the Outside of these, between the Wood and the inner Bark, are larger Tubes, which may do the Office of *Vens*. Now the Root having imbibed Juice from the Earth, this is put into Motion by the Heat. Hereby it is rarefied and caused to ascend in the Form of a Steam or Vapour; till meeting the Mouths of the Arterial Vessels, it passes thro' them to the Top, and to the extreme Parts of the Tree, with a Force answerable to the Heat whereby it is moved. When it arrives there, meeting with the Cold of the External Air, it condenses into a Liquor, and in that Form returns by its own Weight, to the Root of the venal Vessels.

11. From what has been said it plainly appears, that there is a considerable *Agreement between Plants and Animals*, as well with Regard to their Nutrition, as to the Structure of their Part. Some extend this farther, and think there is something in Plants answerable to *Respiration* in Animals. They suppose the Spiral Fibres to be in the place of Lungs, and to serve this very Purpose: That in each of these there is a spiral Lamina, which is extended or contracted, as it is impelled this Way or that, by the elastic Air it includes: That these Fibres ascending strait thro' the Trunk, are dispersed thro' all the Branches, and thence into the Leaves, where they are woven together in a kind of Net-work. By this Means the more subtle Parts of the Air are strained thro' those spiral Fibres, to keep the Juices of the Plant fluid, and perhaps to supply them with Nitre or Ether, to assist their Fermentation.

The Air enters Vegetables various Ways, by the Trunk, Leaves, Roots and Branches. For the Reception as well as Expulsion of it, the Pores are very large in some Plants. So one sort of Walking-canes seem

full of large Pin-holes, resembling the Pores of the Skin in the Ends of our Fingers. In the Leaves of the Pine, if viewed thro' a Glass, they make an elegant Show, standing as it were, in Rank and File, throughout the Length of the Leaves.

Air Vessels are found in the Leaves of all Plants, and in many are visible to the naked Eye. For on breaking the chief Fibres of the Leaf, the Likeness of a fine, woolly Substance, or rather of curious, small Cobwebs may be seen to hang at both the broken Ends. Now these are the Fibres of the Air-vessels, loosed from their spiral Position, and drawn out in Length.

The Pores in the Leaves of Plants are almost innumerable. Mr. *Leuwenhoeck* found above an hundred, and seventy-two thousand, on one side of a Leaf of Box. The Leaves of *Rue* are as full of Holes as an Honeycomb. Those of *St. John's Wort* likewise appear full of Pin-holes to the naked Eye. But the places where those Holes seem to be, are really covered with a thin and white Membrane. Thro' a Microscope the Backside of the Herb *Mercury*, looks as if rough with Silver; and all the Ribs are full of white, round, transparent Balls, fastened by slender Stalks, like so many Grapes. A *Sage-leaf* appears like a Rug or Shag, full of Tufts of Silver-thumbs, and embellished with round, chrystal Beads, fastened by tender Foot-stalks. The Prickles of a *Nettle* are formed for acting just as the Sting of Animals. Every one of them is hollow, and terminates in a fine Point, with an opening near its End. At the Bottom of each Prickle lies a pellucid Bag, containing a clear Liquor, which upon the least touching the Prickle, is ejected at the little Out-let, and if it enters the Skin causes Pain and Inflammation, by the Pungency of its Salts.

The Leaves of Plants are of great Consequence to their Life. At these the Air passes in, and goes thro' the whole Plant, and out again at the Roots. If the Leaves have no Air, the Plant will die, as is easily proved by the Air-pump: Whereas if the Leaves be left on the Outside of the Receiver (parted by a Hole cemented with Wax) while these have Air, the Plant will thrive and

and grow, tho' its Roots and Stalks are kept in Vacuo. The Leaves likewise chiefly perform the necessary Work (But who can explain the Manner!) of altering the Water received at the Roots, into the Nature of the Juices of the Plant. And hence it is, that the Life of Plants depends so immediately upon their Leaves. The Husbandman often suffers, for want of this Knowledge. A Crop of *Saint-foin* is valuable; and its Roots being perennial, will yield an Increase many Years. But it is often destroyed at first, by suffering it to be fed upon by Sheep. For if they eat up all the Leaves, the Root can't be supplied with Air, and so the whole perishes.

Leaves being so necessary in all perennial Plants, a reversionary Stock of them is provided. The Leaves of these Plants are always formed in Autumn, tho' not unfolded 'till the following Spring. They then open and increase, in Proportion to the Motion of the Sap, and the Quantity of Nourishment the Plant receives. These Leaves also, tho' not yet appearing out of the Bud, may suffice for the extremely small Motion, which the Sap of those perennial Plants, that drop their Leaves, has in Winter.

But beside these Autumnal Leaves, there is another set formed in Spring and expanding 'till Midsummer. These are of infinite Service to many sort of Trees, particularly to the Mulberry, as they save its Life, when the first Set of Leaves have been all eaten up by the Silk-worms.

The Analogy between the Parts of Plants and those of Animals may now more fully appear. The Parts of Plants are 1. The *Root* composed of Absorbent Vessels, analogous to the Lacteals in Animals: Indeed performing the Office of all those Parts of the Abdomen, that minister to Nutrition: 2. The *Wood*, composed of capillary Tubes running parallel from the Roots, altho' the Apertures of them are commonly too minute to be seen. Thro' these, which are analogous to *Arteries*, the Sap ascends from the Root to the Top: 3. Those larger Vessels, which are analogous to *Veins*. Thro' these it descends from the Top to the Root: 4. The *Bark*, which communicates with the Pith by little Strings, passing between

the Arteries. 5. The *Pith* consisting of transparent Globules, like the Bubbles that compose Froth.

The Sap enters the Plant in the Form of pure Water, and the nearer the Root, the more it retains of that Nature. The farther it goes, the more it partakes of the Nature of the Plant. In the Trunk and Branches it remains acid. In the Buds it is more concocted. It is farther prepared in the Leaves, (as Blood in the Lungs) which being exposed to the alternate Action of Heat by Day, and Cold by Night, are alternately dilated and contracted.

Is not then the Motion of the Sap in Plants, (like that of the Blood in Animals) produced chiefly by the Action of the Air? All Plants have the two Orders of Vessels, 1. Those which convey the nutritious Juices, 2. Air-vessels, hollow Tubes, within which all the other Vessels are contained. Now the least Heat rarefies the Air in these Air-vessels, thereby dilating them, and so causing a perpetual Spring, which promotes the Circulation of the Juices. For by the Expansion of the Air-vessels, the Sap-vessels are prest, and the Sap continually propelled. By the same Propulsion it is comminuted more and more, and so fitted to enter finer and finer Vessels. While the thicker Part is deposited in the lateral Cells of the Bark, to defend the Plant from Cold and other Injuries.

Thus is every Plant acted on by Heat in the Day-time, especially in Summer; the Sap protruded, then evacuated, and then exhausted. In the Night the Air-vessels being contracted by the Cold, the Sap-vessels are relaxed, and disposed to receive fresh Food, for the next Day's Digestion. And thus Plants do, as it were, eat and drink during the Night-Season.

The Vessels themselves consist of mere Earth, cemented by Oil and Water: Which being exhausted by Fire, Air or Age, the Plant returns to its Earth. Thus in Plants, burnt by the fiercest Fire, the Matter of the Vessels is left entire: Which consequently is neither Water, Air, Salt, nor Sulphur, but Earth alone. The Sap consists of some soluble Parts; others derived from Air, Rain and putrified Plants or Animals. Consequently in Plants

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are contained, Salts, Oils, Water, Earth : and probably all Metals too. In Fact, the Ashes of all Vegetables yield something, which the Loadstone attracts.

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a Plants do likewise *perspire*. To find the Quantity imbibed and *perspired* by Plants. Dr. Ha's took a Pot with a large *Sun-flower* planted in it, and by various Experiments found, the greatest Perspiration in a very warm Day, to be one Pound, fourteen Ounces; the middle Perspiration, one Pound, four Ounces. It perspired three Ounces in a warm Night, when there was no Dew. If small Dew fell, it perspired nothing, if a large Dew, it gained two or three Ounces.

The Weight of the Flower was three Pounds : The Weight of a well-sized Man is 160. The Flower perspires twenty-two Ounces in 24 Hours : The Man about 25 : (besides six Ounces, which are carried off by Respiration from the Lungs.)

A middling Man eats and drinks in 24 Hours, about four Pounds, ten Ounces. The Plant imbibed and perspired in the same Time twenty-two Ounces. But taken Bulk for Bulk, the Plant imbibes seventeen Times more Food than the Man. For deducting five Ounces for Faeces, there will remain but four Pounds, five Ounces, which enter the Veins and pass off in twenty-four Hours. And since taken Bulk for Bulk, the Plant imbibes so much more Food than the Man, it was necessary, by giving it an extensive Surface, to provide for a plentiful Perspiration, since it has no other Way of discharging Superfluities, as a Man has. It was necessary likewise that the Plant should imbibe a larger Quantity of fresh Fluid than the Man, because the Fluid filtrated thro' its Roots does not contain so many nutritive Particles, as the Chyle which enters our Veins.

But there is a Latitude of Perspiration both in Men and Plants. In this Flower it varied from sixteen to eighteen Ounces during twelve Hours Day, as it was watered less or more : In an healthy Man it varies from a Pound and Half to three Pounds.

Ever-greens perspire far less than other Plants. In Proportion, they need less Nourishment : Hereby they are better able to bear the Winter : Like Insects, which as they perspire little, live the whole Winter without Food.

In order to try whether any Sap rose in Winter, he made various Experiments : From all which it appeared, it does rise then also, but in small Quantities. And hence we see, why an *Ever-green* grafted on an Oak will remain verdant, when the Oak-leaves drop. Perspiring less, it needs less Nourishment than the Oak, and so is sufficiently fed by the Sap that rises even in Winter.

In Summer, when hot Sunshine follows a Shower, the Vines in the Middle of an Hop-ground, are often all scorched up, almost from one End of a large Ground to the other : At the same Time the Vapours ascend plentifully. The scorching of the Vines seems to be caused by these scorching Vapours, which ascend most in the Middle

There is a considerable Difference as to the Time when different Plants revive after the Winter. No sooner does the Sun begin to warm the Earth, than the vernal Flowers appear, and the Trees, one after another, open their Buds, and cloathe themselves with Leaves. But why do many Wood plants, as Coltsfoot, Pile-wort, Violets, and many Garden-plants, as Snowdrops, Aslars-bacca, Crocus, flower in the very Beginning of Spring, when we cannot by any Pains or Care, bring them to flower after the Summer Solstice? Nay, these very Plants, which are so patient of Cold in Spring, are in the Autumn so very weak and tender, that they die on the first Touch of Frost. Why, on the Contrary, do Thistles and many other Plants, never flower before the Summer Solstice?

In the same Manner, Trees observe fixt Laws, and a certain Order in their Leafing. Does the Cause lie in the

of the Ground, the Air there being more dense, and consequently better than on the Outfides.

The white Clouds likewise which appear in Summer-time, occasion a vehement Heat, by reflecting many of the Solar Rays, which otherwise would not touch the Earth. And if the Sun be on one Side, and the Clouds on the other, they are perfect Burning-glasses.

Sometimes there is a Kind of hollow Clouds, full of Hail or Snow. During the Continuance of these the Heat is extreme, since by such condensation they reflect more strongly. By these likewise those Blasts may be produced, as well as by the Reflection of dense Vapours.

The Sun-flower being tender, if the Sun rises clear, faces to the East. The Sun continuing to shine, at Noon it faces to the South, and at Six in the Evening to the West. The Cause is, that Side of the Stem which is next the Sun, perspires the most, and thereby shrinks.

"What Degree of Heat will Plants bear?" The common temperature Point in *The Thermometer* is 58 Degrees. The external Heat of an Human Body, will raise it to 54 Degrees. Very hot Sunshine will raise it to 88. Plants endure a considerably greater Heat than this, near the Line, for some Hours a Day. But the hanging of the Leaves of many of them shews, they could not long submit under it.

The Winter Heat is from the freezing Point to Ten Degrees; the Vernal and Autumnal, from 10 to 20. The May and June Heat, is from 17 to 30, in which the Generality of Plants flourish

the different Depth of their Roots? If so Shrubs would have Leaves before Trees of the same Kind. But they have not. We can only say, the Fact we know, but the Reason of it we know not.

The Order of the Leafing of several Trees and Shrubs, observed in *Norfolk* in 1755 was as follows.

1. Honey Suckle,	—	—	January 15,
2. Gooseberry, Currant, Elder,	—	—	March 11,
3. Birch, Weeping-willow,	—	—	April 1,
4. Raspberry, Bramble,	—	—	— 3,
5. Briar,	—	—	— 4,
6. Plum, Apricot, Peach,	—	—	— 6,
7. Filbird, Sallow, Alder,	—	—	— 7,
8. Sycamore,	—	—	— 9,
9. Elm, Quince,	—	—	— 10,
10. Marsh-Elder,	—	—	— 11,
11. Wych-Elm,	—	—	— 12,
12. Horn-Beam,	—	—	— 13,
13. Apple-Tree,	—	—	— 14,
14. Abel, Chestnut,	—	—	— 16,
15. Willow,	—	—	— 17,
16. Oak, Lime,	—	—	— 18,
17. Maple,	—	—	— 19,
18. Walnut, Plane, Black Poplar, Beech,	—	—	— 21,
19. Ash, Carolina Poplar,	—	—	— 22,

Indeed

best. The Heat of July is, in the Shade, about 38 Degrees. In the Sunshine, at Noon, about 50. The Heat of an Hot-bed, when too hot for Plants, is 85 or more; And near this is the Heat of the Blood in high Fevers. The due Heat of an hot Bed is 56 Degrees; and the same Heat hatches Eggs.

A continual Steam is ascending during the Summer; the Sun-beams giving the Moisture of the Earth, at two Foot Depth, a brisk, undulating Motion, which rarefied by Heat, ascends in the Form of Vapours. And the Vigour of warm and confined Vapour (such as is that which is a or 3 Feet deep in the Earth) must be great, and penetrate the Roots with some Vigour; as we may reasonably suppose, from the vast Force of confined Vapour in the Engine for raising Water by Fire.

The Vegetables have not, like Animals, an Engine which by its alternate Dilatations and Contractions, drives their Juices thro' them, yet has Nature contrived other Means, powerfully to raise the Sap and keep it in Motion. And their Roots are covered with a

Indeed the Leafing of several of these varies much, as the Spring is earlier or later. But others of them, be the Winter ever so mild, do not put out before their Time. This also depends on some secret Properties, which Man is not able to explain.

That the Leaves of certain Plants assume at Night a Disposition different from that of the Day, is well known. But to what is this owing? Not to the Variation of Heat or Cold, Moisture or Dryness. For however these are varied, the same Thing happens with equal Regularity. It is Light alone that occasions this Change, which by the Smallness of its Particles, is capable of entering Bodies, and by its Activity, of producing great Changes in them. It changes the Position of the Leaves of Plants, by a Motion it excites among their Fibres. The natural Position of the Lobes

very fine, thick Strainer, that nothing may enter but what can be readily carried off by Perspiration.

That there is a *lateral Communication* of the Sap-vessels in Plants, as of the Blood-vessels in Animals, plainly appears from the Experiment of inarching Trees. For when three Wall-trees are thus incorporated, the Root of the Middlemost may be dug up, and the Tree will grow still, as receiving Nourishment, from the Trees with which it is connected. And hence Elders, Willows, Vines and most Shrubs, will grow with their Tops downward in the Earth. For the same Reason, if you frequently, in an Evening, wash the Bodies of new-planted Trees, they will grow quicker and better than any others of the same Plantation.

Whether the Sap in Plants circulates or no, is still warmly disputed. To the Argument drawn from the *Jessamine-tree*, Dr. Hales replies, "We have many visible Proofs in several Trees, of the Saps receding, and pushing forward alternately, at different Times of the Day and Night." Probably in all Trees, it recedes in some Measure from the Tops of Branches, as the Sun leaves them; because its rarefying Power then ceasing, the rarefied Sap and Air mixt with it, will condense and take up less Room, and the Dew and Rain will then be strongly imbibed by the Leaves: And the Body and Branches which have been exhausted by the Evaporation of the Day, will imbibe the Moisture from them.

That the Sap does not descend between the Bark and the Wood, as the Favourers of a Circulation suppose, seems plain from hence, That if the Bark be taken off 3 or 4 Inches broad quite round, the Bleeding of the Tree *above* the Place will much abate: Whereas just the Contrary must happen, if the Sap descended by the Bark.

Lobes in these Leaves is drooping. This is their Posture of Repose. But Vegetation is very imperfectly performed, while they remain in it. It is Light which alters that Position, by its quick Vibrations.

In the Evening, *August 7.* (in order to make a full Experiment) Dr. *Hull* placed a Plant of *Abrus*, in a Room where it had moderate Day-light, without the Sun's shining upon it. The Lobes of the Leaves were then fallen perpendicularly from the Middle Rib, and closed together by their under Sides. Thus they continued all Night. Half an Hour after Day-break, they began to separate, and a quarter of an Hour after Sunrise, were perfectly expanded. Long before Sun-set they began to droop again, and toward Evening were closed as at first.

Next Day the Plant was set, where there was less Light. The Lobes were raised in the Morning, but not so much. And they drooped earlier at Evening.

The third Day it was set in a South Window, open to the full Sun. Early in the Morning the Leaves had attained their horizontal Situation: By nine o'Clock, they were raised above it, and continued so till Evening. Then they fell to the horizontal Situation, and thence gradually to the usual State of Rest.

The fourth Day the Plant stood in the same Place, but the Sun did not appear. The Lobes early attained their horizontal Situation, but did not rise beyond it, and in the Evening, closed as usual.

These Experiments prove, that the whole Change is occasioned by Light only. To put this beyond Dispute, in the Evening of the sixth Day, the Plant was set in a Book-Cast, on which the Morning Sun shone, the Doors standing open. The next Day was bright. The Lobes which had closed in the Evening, began to open early in the Morning, and by nine o'Clock, they were raised in the usual Manner. I then shut the Doors of the Book-cast; on opening them an Hour after, the Lobes, were all closed as at Midnight. On opening the Doors, they opened again, and in twenty Minutes they were fully expanded. This has since been many Times repeated, and always with the same Success. We can

can therefore, by admitting or excluding the Light, make the Plant put on all its Changes. Hence we are certain, that what is called the *Sleep* of Plants, is caused by the Absence of Light alone, and that their various intermediate States are owing to its different Degrees.

It has been supposed that the daily Motions of the *Sensitive Plant*, were likewise owing to Light and Darkness; because it expands itself in the Morning and closes again in the Evening. From the main Branches of this Plant spring several smaller ones, and from these others still less, which support the Leaves, ranged on each Side, in Pairs over against one another. Several other Plants are of the same Form, and all these close their Leaves in the Evening, and open them in the Morning, which therefore is not peculiar to the sensitive Plant. But this closes them at any Time of the Day, if touched, and soon after opens them again. You can scarce touch the Leaf of a vigorous, sensitive Plant so lightly, as not to make it close. The large Rib which runs along its Middle, is as an Hinge, on which the two Halves of the Leaf move, when they turn upon being touched, till they stand erect, and by that Means meet one another. The slightest touch gives this Motion to one Leaf; if a little harder, it gives the same Motion to the Leaf opposite. If the Touch be still rougher, the whole Arrangement of Leaves on the same Rib close in the same Manner. If it be stronger still, the Rib itself moves upward toward the Branch on which it grows. And if the Touch be yet more rough, the very Branches shrink up toward the main Stem. The Motion which has the greatest Effect of all others upon it, is the shaking one. Winds and heavy Rains also cause this Plant to close its Leaves; but not gentle Showers: The Contraction being caused by the Agitation of the Wind, and the Strokes given by the large Drops.

The natural shutting and opening of its Leaves at Night and Morning, are not so fixt, as not to be variable by many Circumstances. In *August* a sensitive Plant was carried in a Pot into a dark Cave. The Shaking in the Carriage shut up its Leaves, so that they did not open for four and twenty Hours. And when they did open, they

closed

closed no more for three Days and Nights. Being then brought again into the open Air, they recovered their natural Motions, shutting at Night and opening in the Morning, as variously as ever. While in the Cave, it was as much affected by the Touch, as in the open Air.

By this and many Experiments it appears, that it is not the Light that opens these Plants, nor the Darkness which shuts them. Neither is it owing to the Increase of Heat or Cold. Indeed great Heat will affect them a little, but not in any considerable Degree. Concerning the real Cause, we may form many Conjectures: But nothing certain can be known.

12. As to the *Generation* of Plants, first the Tree produces *Buds*, which afterward expand into Leaves, Flowers or Branches. In the Buds entire Plants are contained. A small Stalk, consisting of woody and spiral Fibres, springs out of the Middle of the Plant, wherein the Bud inheres. It is involved in a thin Bark, which may be divided into various Leaves, lying one upon another like Scals.

13. Buds are followed by Leaves and Flowers. ^b The Flower is as it were the Womb, which contains the Eggs or Seeds of Plants, and in due Time brings them forth. It is near the Bud, and lies hid with it during the Winter, till it is brought out by the Heat of the Summer. The most simple Plants bear a Bud, which contains

^b In Flowers we may consider, 1. The *Calix* or outer Cup, designed to be a Security to the other Parts of the Flower, Those whose Leaves are firm and strong, as *Tulips*, have no Calix at all. *Carnations*, whose Leaves are strong, but slender, have a Calix of one Piece. Others have it consisting of several Pieces, and in divers Rounds: 2. The *Foliation* or *Petals*, the *Flower-leaves*, which are properly the Flower itself. In these not only the admirable Beauty, and luxuriant Colours are observable, but also their curious *Foldings* in the Calix, before they are expanded.

It is remarkable, that many, if not most Vegetables, especially those of a tender Kind, expand their Flowers, or Down, every Day, if it be warm, sun-shiny Weather. But they close them, as the Evening approaches; and some, at the approach of Rain. This is particularly done, at the beginning of Flowering, while the Seed is young and tender: As is easily seen in the Down of *Dandelion*, and eminently in the Flower of *Pimpernel*. These serves as a Weather-Glass to the Countryman: By the opening or shutting of these, he can tell, without any Danger of being deceived, whether the Weather will be foul the next Day.

contains a Seed, of an Oval Figure. We may easily distinguish from the Flower itself, the *Leaves* of the Covering which involves the Bud. From these arise the *Leaves* of the Flower, serving for the last Concoction of the Sap; in which are both woody and spiral Fibres, with various Rows of Utricles. In the Middle of Flowers *Filaments* and *little Pillars* arise, whose Extremities are covered with a Kind of *Dust*. These Pillars are Hollow, and have Vessels full of Liqueur, and the Rudiments of Seeds, which gradually grow and harden.

This Dust is of two Kinds, Male and Female. The Male Dust is formed in the Top of the Filaments, where when it is ripe, it bursts its Case, and is split on the Heads of the Pillars, and thence conveyed to the Utricle or Matrix thereof, to impregnate the Female Dust contained therein.

This Dust in any one Plant being viewed with a Microscope, every Particle is of the same Size and Figure. But in different Plants, the Colour, Size and Figure are widely different. In some it is clear and transparent, as Chrystal; in others, white and opaque; In some, blue, purple or red, and in others, flesh-coloured. And its Colour varies in the same Species, suppose Tulips, according to the Colour of the Flower.

The most general Figure is the Oval, more or less Sharp at the Ends, with one or more Furrows running Lengthways. But the Seeds of *Melilot* are Cylinders. Those of the *Pansy* are Prisms, with four irregular Sides. Others represent two Chrystal Globules fastened together. Those of the *Junquil* are in the Form of a Kidney. But indeed the Varieties are not possible to be numbered.

The

The Seeds of the several Species of *Fern*, were wholly unknown to the Antients. But it is now well known, that in the Female Fern, the whole Surface of the Leaf on the Under-side is covered with a Congeries of Seeds, so that they guard one another, and need no other Covering. And in the common Male Fern, there are found at the proper Season, several brown Spots, placed in a very regular Manner. These are a fungous Matter, round which the small Seed-vessels are inserted.

The Fruitfulness of Plants, in producing Seeds, transcends all Imagination. An Elm living an hundred Years, ordinarily produces

The Office of the *Blossom* is partly to protect, partly to draw Nourishment to the Embryo, Fruit or Seed. The Gourd, Pumkin, Melon, Cucumber, and most bearing Trees, have both Male and Female Blossoms on the same Plant. Male-Blossoms, (usually called *Catkins*) may be distinguished from Female, by having no Pistil or Rudiment of Fruit about them; but only a large Thrum, covered with Dust in their Middle. The Female Blossoms have always a Pistil, within the Flower-leaves; and the Rudiments of the Fruit are always apparent, at the Bottom of the Fruit before it opens.

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X

But

thirty three Millions of Seeds. Add, that if its Head be cut off, it puts forth as many Branches within half an Inch of the Place where it was cut as it had before. And at whatever Height it is cut off, the Effect will be the same. Hence it appears, that the whole Trunk, from the Ground, to the Rise of the Branches, is full of Embryo-Branches, each of which will actually spring forth, if the Head be lopped off just over it. Now, if these had sprung out they would have borne an equal Number of Seeds, with those that did. These Seeds therefore are already contained in them: And if so the Tree really contains 15840000000 Seeds, wherewith to multiply itself as many Times. But what shall we say, if each Seed contain another Tree, containing the same Number of Seeds? And if we can never come, either at a Seed which does not contain Trees, or a Tree which does not contain Seed?

Timber-Trees of any Kind might certainly be planted to more Advantage than they generally are. There is a Forest two Miles from St. Lo, in Normandy, planted chiefly with Oaks, many of which are but of a moderate Height, tho' of a large Circumference. But near its Entrance from St. Lo, there is a Plantation, about twenty-five Years old, wherein none of the Oaks are under seventy, and some an hundred Feet high. They are set so close, that they almost seem to touch one another, and are no more than four or five Inches in Diameter. This Timber is of great Use, both for making Charcoal, and many other Purposes. And the Owners may reap four Crops of them in an hundred Years.

This Forest belongs to the King of France, who ordered the Plantation to be made by Way of Trial. And his Ministers have caused several of the Trees, an hundred Feet high, to be transplanted, to see them branch at the Top, and to leave standing Proofs of the wonderful Effects of the Experiment.

As to *Sowing*, the Perfection of Agriculture consists, in setting Plants at due Distances, and giving a sufficient Depth to the Roots, that they may spread and receive due Nourishment. Yet this is

But there is a Species of Willow, which appears to change its Sex every Year. One Year it produces Male-Blossoms, and Female-Blossoms the next.

14. The Seed, when it is ripe, is inclosed in a peculiar Covering. In some Plants it so increases, as to become a Fruit. And in these also we find Fibres and Utricles dispersed with endless Variety.

Various are the Methods which the Wisdom of God takes for sowing Seeds of various Kinds. Those of *Arum* and *Poppy* are heavy enough to fall directly to the Ground. Others that are light, have *Hooks* to stop them, from straying too far from their proper Place. So have *Agrimony* and *Goose Grass*, the one wanting a warm Bank, the other an Hedge for its Support.

On

little regarded, but all Sorts of Grain are sown by Handfulls cast at Random. By this Means four Parts in five of the Seed is utterly lost. To remedy this a Spanish Gentleman contrived an Engine (described in the *Philosophical Transactions*, under the Name of the *Spanish Sembrador*) which being fastened to the Plow, the whole Business of Plowing, Sowing, and Harrowing, is performed at once: And the Grain is spread at equal Distances, and equally deep in the Furrow. An Experiment being made, Land which usually produced five-fold, by this Means produced sixty-fold. One Stalk is all that springs immediately from one Grain: But on the Sides of this, near, if not within the Ground, issue several lateral Stalks. And some of these send forth Roots, whence one or several other Stalks spring, if they are early formed, the Soil good, and the Weather favourable. By this Means one Grain of Wheat planted in a Garden has produced 90, yea 100 Ears. If then each Ear, taking one with another, contain 50 Grains, a single Grain may produce five Thousand. Nay a Gentleman in *Torshire*, who made the Experiment in his Garden some Years ago, counted upwards of eight Thousand Grains, which sprung from a single one.

After all that has been said and wrote for so many Centuries, on the Generation or Propagation of Plants and Animals, a late Author (to whom the *French Naturalists* in general subscribe) totally denies the whole, and censures all who pretend to discover any Animalcula in the Semen of Animals. He will by no Means allow, that every Animal or Plant, proceeds from an Egg lodged in the Parent Plant or Animal. On the contrary, he supposes, "there are in Matter certain organical Parts, disposed for the Formation of animal and vegetable Substances, which by Coalition constitute the first Stamina of all animal and vegetable Bodies. These are simple,

On the other Hand, many Seeds have *Wings*, that the Wind may carry them off the Plant, and may scatter them afunder, that they may not fall together, and come up too thick. The Kernels of *Pines* have very short Wings, just enabling them to flutter on the Ground. But some Seeds have many long Feathers, by which they are wafted about every where.

Others are lodged in Elastic Cafes, which dart out the Seed to convenient Distances. Thus *Wood-forrel* having a running Root, needs to have its Seeds sown distant from each other. And this is done, by Means of a tendinous Cover, which when it begins to dry, burfts open on one Side in an Instant, and is violently turned inside out. The Seed of *Harts-tongue* is difperfed in a different Manner. It has a Spring wound round its Cafe. When it is ripe, this suddenly breaks the Cafe in two Halves, and fo throws out the Seed. Equally remarkable is the Way wherein *Fern-Seed* is scattered. If a Quantity of this be laid on a Paper, the feminal Veficles burft, and are feen by a Microfcope projecting the Seeds to a confiderable Distance.

X 2

Blue

uniform common to all, and confequently to be found, more or lefs in every Portion of nutritive Juice. From thence they are digefted, and when the Subject becomes adult, fecreted for the Formation of the Seed of every Plant and Animal. Thefe organical Parts, moving when difengaged, and thence imagined to be alive, are extremely fimple in their Composition; being perhaps only elastic Springs, more or lefs compreff, more or lefs diversified in the Direction of their Force.

"All *microfopic Animals*, fo called, are indeed no other than fuch organical Particles. Seeds macerated in Water, firft difunite into fmall Particles, which foon after, move and feem alive, tho' they are not fo. The fame may be obferved of the Juices of Animals, as Mutton-Gravy and the like. And as to the common Imagination that the Male Semen, while in the Veffels, contains Millions of Animalcula-like Tadpoles, it is certain, they are produced, after the Evacuation of the Fluid, and rife from Principles contained therein, by a real Vegetation, and a fubfequent Change from the vegetable to the animal Life.

"Semen immediately evacuated is an homogeneous Fluid. In a few Moments it begins to feparate, and after this a Kind of vege-

Blue-flowered Gentianella requires wet Weather to be sown in. As soon as any Rain touches the Seed-vessels, they burst open and throw the Seed on every Side. *Cardamines* burst their Pods and dart out their Seed, on a slight Touch of the Hand: Nay, the *Cardamine Impatiens* does so, even by the Approach of the Hand. Other Seeds by their agreeable Taste or Smell, invite Birds to feed upon them, who drop them again, fertilized by passing thro' their Body. So *Misseltoe* is usually sown.

The Progress of Germination was accurately observed by *Malpighi* in the Seed of a *Gourd*: The Day after it was committed to the Ground, he found the outer Coat

table Filaments grow in it, and shoot out Ramifications on every Side. These open and divide into moving Globules, which trail after them something like long Tails; which are in Truth only Strings of the viscid Matter, from among which the Globules were separated. By Degrees the Globules get rid of them, and then move at Ease.

"This vegetable Power of shooting into Filaments, is in all animal and vegetable Substances, down to the least microscopic Point. And to this is really owing, all that is called Animal Life, in the Fluids produced from Vegetables.

"In all our Observations on these Substances, the whole Quantity of Matter, after a Separation of some volatile and saline Parts, always divides into Filaments and vegetates into numberless Zoophytes, which afterward yield all the Species of microscopic Animals. After this, these supposed Animals themselves subside to the Bottom of the Liquor, become motionless, resolve into a gelatinous, filamentous Substance, and then afford new Zoophytes or Animals of a smaller Kind.

"Hence we may observe, That every Animal or Vegetable Substance, advances as fast as it can, to resolve into one common Principle, which is the Source of all: A Kind of universal Semen, from which each Atom may again ascend to a new Life. These Animalcula then in the Semen of Animals, and in the Infusions and Juices of animal and vegetable Substances, are not of the Nature of any other Beings, nor to be ranked with them. They constitute a Class apart from all others, the Characteristic of which is, that they neither are generated, nor subsist by Nutriment, like other Plants or Animals, nor do they generate in the ordinary Way."

What then becomes of this whole boasted Branch of Modern Philosophy? If this be so, most of our Microscopic Discoveries, vanish into Air.

Coat a little swelled; and in its Tip a small Cleft appeared, thro' which the Sperm was seen. The second Day the outward Coat was much softer, the Inner torn and corrupted, the Germ somewhat longer and more swelled, and the Beginning of the Root appeared. The third Day, the Root had made itself a Passage thro' the Coat, near the former Cleft. The Germ and Seed-leaves also were now grown much bigger. On the sixth, more of the Seed-leaves had broken thro', and were found thicker and harder. The Root had shot out many Fibres, and the Stem grown a Finger's Length. About the twenty-first Day the Plant seemed complete, from which Time the Seed-leaves began to droop, till they died away.

15. The *Parts* of different *Fruits* are different: But in all, the essential *Parts* of the *Fruit*, are only Continuations of the *Fibres*, observed in the other *Parts* of the *Tree*. And there is a direct Communication between the *Fruit* and the remotest *Part* of the *Tree*. Thus an *Apple* cut crossways appears to consist of four *Parts*. First, the *Skin*, derived from the outer *Bark* of the *Tree*; 2. The *Pulp*, which is an Expansion of the inner *Bark*; 3. *Ramifications* of the woody *Part* of the *Tree*, dispersed throughout the *Pulp*. To these are fastened the *Coats* of the *Kernels*. And these being at first extended to the *Flower*, *Part* of them directly, and *Part* obliquely, furnish it with its *Nourishment*. But the *Fruit* increasing intercepts the *Aliment*: And then the *Flower* is starved and falls off: 4. The *Core*, which is a *Production* of the *Pith* of the *Plant*, strengthened by *Fibres* of the *Wood* intermixt. This is a *Case* for the *Kernels*, filtrates the *Juice* of the *Pulp* and conveys it to them.

Fruits serve not only for the *Food* of *Animals*, but to guard and nourish the *Seed* inclosed; to filtrate the coarser *Part* of the nutritious *Juice*, and transmit only the purest for the *Support* and *Growth* of the *Plantule*.

In every *Sort* of *Grain*, *Wheat*, *Barley*, or any other, there are three *Particulars* observable, 1. The *Outer Coat* which contains all the rest. This in the same

Species of Grain, is of a very different Thickness in different Years, as also in different Soils: 2. The *Germ* or *Bud*, This is always hid in the Grain, and is the Plant in Miniature; and 3. The *Meal* which is inclosed in the Skin, that surrounds the Germ and gives it Nourishment, when first put into the Earth, before it is capable of drawing it from the Earth itself.

The whole Structure of the Plant which produces these Grains is equally admirable. The *chaffy Husk* is well adapted to defend the Grain, as long as that is necessary, and then to let it fall: The *Stalk*, hollow and round, is at once light and strong, capable of sustaining the Ear, without absorbing too much of the Juices destined for its Nourishment. And the *Beards* are a Defence against the Birds, that would otherwise destroy the Grain before it ripened. The *Covering* of the Grain is formed of Fibres, which meet in a Line and form a Kind of Furrow. This is the Place at which the Seed, when moistened, is to burst open. Were not this Means prepared for the Germ's coming out, the Toughness of the outer Coat, would have kept in both the Meal and the Germ, till they had rotted together.

Nor is this the only Use of this Place of Opening. The Grain is designed, not only for Seed, but for Food also. Men have Art enough to erect Machines, for reducing it to powder. But the Birds eat it as it is, and it would pass them whole, without doing them any good, were it not, that when it is moistened, it bursts open at the Furrow and yields them Nourishment.

The Meal is composed of an infinite Number, of round, white, transparent Bodies. These inclose the young Plant, and by their Figure being easily put in Motion, as soon as affected by the Heat and Moisture of the Earth, they insinuate into the Vessels of the Plant, and give it increase, till it is in a Condition to feed on the Juices of the Earth. The same Process of Nature is observable, when Grains of Corn grow out of Time, on being thrown carelessly together, in a moist Place.

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I cannot better conclude this Chapter, than by tracing the *Analogy* between the *Propagation* of Animals and that of Vegetables. The Roes of Fishes, the Eggs of Insects, Birds and all other Animals, nearly resemble each other. They are compact Bodies of such Forms as best suit their Natures. They all have integuments nobly contrived for their Preservation, with firm Coverings, to secure them from outward Injuries. Those to be kept in the Body have Coverings also; but soft and membranous. Every Kind contains its peculiar Substance, differing from that of every other Kind. And all these Characters belong also to *Seeds* of every Kind. They have their Coverings, more or less compact, according to their Necessities. Their Forms are convenient. The Substances they contain are specifically different from each other: and their Offspring proceeds from them in the same Manner, as Animals proceed from their Eggs.

But beside the Substances peculiar to each Seed, there is a peculiar Organization treasured up in each, which is the Rudiment of the future Plant, capable of being propagated into such a Plant as it sprung from, and no other. So in every one of the Nut-kind, there is a visible Organization, peculiar to each Species. And if such Organization appear in every Seed, which is large enough to be viewed clearly, we cannot reasonably doubt of their Existence, even in those which are so small as to escape our Sight. There are Multitudes of Seeds, which produce large Plants, and yet appear only like Dust, and a vast Number, which we cannot see, but by the Microscope. And yet these doubtless have all their peculiar Forms, and their Organizations as well as the larger.

But from what are these Organizations produced? How does every Plant or Animal, bring forth a fresh one after its Kind? A little of this we may understand, if we trace a Tree and an Animal thro' every Stage, from the Egg, to their utmost Growth.

See a young Tree pushing out its Leaves and Flowers, till it has extruded an entire Set of Boughs and Branches. One Part regularly opens after another, from

from the first Shoot, till it comes to Perfection. Then and not before, it produces Seeds, containing the Rudiments of other Trees like itself. The Fibres of its general Organization grow into little Knots, some to form Leaves, some the Calix, some the Petals, some the Pistil and Utricle, some again the little Seeds, each growing from its own Pedicle. For the Male Parts, other Fibres are formed into Stamina, and from these terminate into Apices: And again from these, others terminate into the minute Grains, commonly called the *Farina fecundans*; each Grain growing on its own Pedicle, just as the Leaves or Fruits of Trees.

See an Animal, exactly in the same Manner, unfolding itself by Degrees, till its Parts are explicated entirely, and it is complete in every Organ. Then and not before each Female is capable of producing Eggs, each being a Continuation of the General Organization; and growing upon its own Pedicle. Each Male likewise, when at its State of Perfection, is capable of producing from itself the fecundating Matter, necessary for the Propagation of the Species.

Let us again view a full grown Tree or Plant, putting forth its Parts for Frustrification. Observe the Apices, on the Stamina, loaden with the Globules of the *farina fecundans*, the Pulp of each Globule containing an exalted Fluid, and conveying it to one of the Papillæ of the Pistil. The Utricle is now filled with green, soft Seeds, ready to be impregnated by the Globule, and containing a Fluid, which afterward becomes a hard Covering to each. And within this the little Organizations gradually increase.

As then a refined Fluid from the seminal Matter of the Male, impregnates the Organization in the Egg of a female Animal, mingles with the subtle Fluids contained therein and promotes its Growth and Progress: So the refined Part of the pulpy Fluid contained in the Globule, impregnates the Organization in the Seed of a Plant, mixes with its Juices, and gradually promotes its Growth into a perfect Plant. And doubtless both the impregnating Effluvia of Animals and Vegetables, and the innate Juices of the Organization, have

have Qualities peculiar to themselves. Hence the Offspring of a black and a white Parent, is of a Colour between both. And thus if the Farina of one Sort of Flower impregnate the Egg of another, the Colour of the Flower produced thereby is variegated proportionably.

The Juices imbibed by a Plant, being composed of innumerable various Substances, after every Part has attracted its kindred Particles, the superfluous ones are carried off by Perspiration: Chiefly by the Leaves, which are the Emunctories, that throw off those Juices which have no kindred Particles in the Plant. Accordingly when the warm Sun begins to rarefy the Fluids, which during the Winter were condensed and inactive, the new Leaves then begin to put forth, from their several Organizations. When Winter comes, as no more Fluids ascend in Trees, so there is no Perspiration. Consequently most of them need Leaves no longer, which therefore fall off. Nor are they succeeded by others, till the Vegetable begins to receive fresh Nourishment, and has Occasion therefore for excretory Vessels to carry off Superfluities. Just so the superfluous Juices in Animals, are continually carried off by Perspiration: An Obstruction of which is equally pernicious to Animals and Vegetables.

But is there any Thing in the vegetable Kingdom, analogous to that strange Animal, the *Polypus*, which multiplies by being cut in Pieces? There is. View, for Instance, a young Willow. This is an organized Body, capable of growing, till it come to its perfect Growth, by Means of the vegetative Principle. The *Polypus* is an organized Body, capable of being extended till it come to its perfect Growth; and of Feeding and Loco-motion, by its animating Principle. The Willow as it grows, is gradually sending off new Branches, which are its Fœtuses, proceeding from the Organizations lodged in every Part. The *Polypus* in like Manner gradually sends off new Fœtuses; from Organizations placed in every Part of it. If the Willow be cut in Pieces and planted, each Piece will
be

be explicated into a Tree, and then send forth new Fœtules, like its Parent. And if the Polypus be cut in Pieces, each Piece will be explicated into a Polypus, and then extrude new Fœtules. So that cutting it in Pieces, is but anticipating the Propagation of those Organizations in the Pieces, which would, if let alone for a while, themselves issue from the Sides of the Parent.

If we observe the extreme Tenderness of this Animal, liable to be wounded, nay torn in Pieces, by any hard Body, which is carried down the Streams, or moved in the Ponds wherein they dwell: We see the providential Reason, for this Contrivance to propagate them: As perhaps no other Animal is of so tender a Texture, and so easily destroyed, having neither sagacity to avoid Danger, nor Strength to bear the least Violence.

C H A P. II.

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| 1. <i>Of some particular Plants.</i> | Plants and Animals: |
| 2. <i>Of the Corruption of</i> | 3. <i>General Reflections.</i> |

1. **I**T remains, to give a short Account of some remarkable Productions of the Vegetable Kind.

Pepper grows on a Shrub in several Parts of the *East Indies*, which is of the Reptile-kind; and for that Reason is usually planted at the Foot of some larger Tree. It grows in Clusters, which at first are green. As the Grains ripen, they grow reddish; and after being exposed a while to the Sun, become black. To make *White Pepper*, they moisten it with Sea-water, and then exposing it to the Sun, divest the Grains of the outer Bark, which of Consequence leaves them white.

The Plant which affords *Ginger*, resembles our Reed, both in its Stem and Leaves. The Root spreads itself near the Surface of the Ground, in Form not unlike a

Man's

Man's Hand. When it is ripe they dig it up, and dry it either in the Sun, or in an Oven.

Nutmegs are inclosed in four different Covers: The first, thick and Flešhy, like that of our Walnuts: The second is a thin, reddish Coat, of an agreeable Smell, called *Mace*. The third is a hard blackish Shell. The fourth is a greenish Film. In this the Nutmeg is found, which is properly the Kernel of the Fruit.

Sago is procured from a Tree growing in the *Molucca* Islands. They cleave this, and take out the Pith, which they pound in a Mortar to a Kind of Meal. They then put it in a Searse over a Cistern, and by pouring Water upon it, separate the pure Part of the Powder, from the Veins of Wood. This Flower they make into Paste, and bake in an earthen Furnace.

The Tree which produces *Cotton* in common in several Parts both of the *East* and *West-Indies*. The Fruit is oval, about the Size of a Nut. As it ripens, the Outside grows black, 'till opening in several Places by the Heat of the Sun, it discovers the Cotton, of an admirable Whiteness.

The *Tallow-tree* which grows plentifully in *China*, is about the Height of a Cherry-tree. Its Bark is very smooth and its Leaves of a deep, shining Red. Its Fruit grows in a Pod, like a Chesnut, consisting of three white Grains: Each of which is about the Size, and of the Form of a small Nut. In each is a little Stone, surrounded with a white Pulp, in Consistence, Colour, and even Smell like Tallow. And this it is, of which the *Chinese* in general make their Cand'es.

The *Coco-tree* grows streight, without any Branches thirty or forty Foot high. Near the Top it bears twelve Leaves, each ten Foot long, and half a Foot broad. These are used in making Mats, covering Houses, and for many other Purposes. Above the Leaves grows a large Excrecence, in the Form of a Cabbage. But the taking it off kills the Tree. Between the Leaves and the Top grow several Shoots, as thick as a Man's Arm, which when cut, yield a white, sweet, agreeable Liquor, serving as Wine, and equally intoxicating. Yet at the End of four and twenty Hours, it becomes a strong Vi-
negar

negar. As long as this Liquor distills, the Tree bears no Fruit : But when these Shoots are suffered to grow, it puts forth a large Bunch, wherein the Coco-Nuts are to the Number of ten or twelve. In each there is first about half a Pint of clear, cooling Water. In a little while this becomes a white, soft Pulp, which afterward condenses into a Nut. The Tree yields Fruit thrice a Year. Some of the Nuts are as large as a Man's Head.

The *Wild-pine*, as it is called, is a wonderful Instance of the wise Providence of God. The Leaves of it are channelled, to catch and convey Water into their Reservoirs. These Reservoirs are so made, as to contain much Water. And they close at the Top when they are full, to hinder its Evaporation. These Plants grow on the Arms of the Trees in the Woods, as also on the Bark of their Trunks. Another Contrivance of Nature in this Vegetable is very admirable. The Seed has many long and fine Threads, that it may be carried every where by the Wind, and that by these when driven thro' the Boughs it may be held fast, and stick to the Arms or Trunks of Trees. As soon as it sprouts, altho' it be on the under Part of a Bough, its Leaves and Stalk rise perpendicular, because if it had any other Position, the Cistern made of hollow Leaves could not hold Water, which is necessary for the Life of the Plant, in Scarcity of Water, this Reservoir is not only necessary and sufficient for the Plant itself, but likewise useful to Men, Birds and Insects. Hither they then come in Troops, and seldom go away without Refreshment.

These Leaves will hold a Pint and an half, or a Quart of Rain-water. When we find these Pines, says Captain *Dampier*, we stick our Knives into the Leaves, just above the Root; and that lets out the Water, which we catch in our Hats, to our great Relief.

The same Providential Design is answered by the *Water-with* of *Jamaica*. This, which is a Kind of Vine, grows on dry Hills in the Woods, where no Water is to be found. Its Trunk, if cut into Pieces, two or three Yards long, and held by either End to the Mouth, affords a limpid, innocent and refreshing Sap, as clear as Water :

Water: And that in so great Abundance, as gives new Life to the weary and thirsty Traveller.

But of all Productions of the vegetable Kind, there is none more remarkable than the *Aloe*. It grows exceeding slowly. But the Slowness of its Growth is afterwards compensated, by the Bulk to which it arrives, the Velocity with which it shoots, and the prodigious Number of Flowers it produces, which ordinarily amount to several Thoulands. It usually takes up three Months, May, June and July, from the first budding of the Stem, to the finishing of the Flowers. There are however Exceptions to this Rule. The *Aloe* in the Garden of Cardinal *Farnese* at *Rome*, shot up in the Space of one Month, to the Height of twenty-three Feet. Another at *Madrid* grew ten Feet in one Night, and twenty-five more, in the Night following.

The Progress of the *Venetian Aloe*, in the Garden of Signior *Papatava*, was as follows. It began to shoot its Stem on the 20th of May, which by the 19th of June, was risen 4 *Paduan* Feet and an Inch. On the 24th it had gained ten Inches more, and on the 29th eight more, on which Day it began to emit Branches. On the sixth of July it had gained one Foot, one Inch; on the 17th one Foot, eight Inches more, on the seventh of August, one Foot and an half. From that Day to the 30th, it grew very slowly, but continued emitting Branches and Flowers. The Trunk was at the Bottom a Foot thick; the Branches were twenty three in Number. On the Top of each was a Knot or Collection of Flowers. On each of the first Branches there were an hundred and twelve; on others an hundred and ten, and on others an hundred. They yielded little Smell; but what was of it was agreeable.

When the Tree has once flowered, it quickly dies, being quite exhausted by so copious a Birth. They seldom flower till they are of a considerable Age, when they are of a large Size and a great Height. As soon as the Flower-Stem begins to shoot from the Middle of the Plant, it draws all the Nourishment from the Leaves, so that as that advances, these decay. And when the Flowers are fully blown, scarce any of the Leaves remain

main alive. But whenever this happens, the old Root sends forth a numerous Quantity of off-sets for Increase.

Perhaps there is scarce any Plant in the Creation which is of so general Use. The Wood of it is firm, and serves for Fences, and for the Use of the Carpenter. The Leaves make Coverings for Houses: The Strings and Fibres serve, in the Room of Hemp, Flax and Cotton. Of the Prickles are made Nails and Awls, as also Pins and Needles. And from a large Aloe, when rightly tapped, may be drawn three or four hundred Gallons of Juice, which by Distillation grows sweeter and thicker, 'till it becomes Sugar.

It has been before observed, That as all Animals are from Eggs, so all Vegetables are from Seeds. But many have supposed, there is one Sort of Vegetable, which is an Exception to this: Namely, *Mushrooms*, the Seeds whereof have been long sought in vain. And it is certain, if you only range in April, Balls of Horse-dung, as big as one's Fist, in Lines three Foot distant from each other, and one Foot under the Ground, covering them all over with Mould, and that again with Horse-dung: In the beginning of August the upper Pieces of Dung will begin to grow white; being covered with fine white Threads, woven about the Straws whereof the Dung is composed. By Degrees the Extremities of these Threads grow round into a Kind of Button; which enlarging itself by little and little at Length forms itself into a Mushroom. At the Foot of each, when at its full Growth, is an infinity of little ones. The white Threads of the Dung preserve themselves a long Time without rotting if kept dry. And if they are laid again in the Ground, they will produce new Mushrooms.

"Are these then any Thing else than the Mouldiness or Putrefaction of Horse-dung? Yes certainly. Indeed all *Mouldiness*, so called, is a Congeries of very small Plants. And these in particular, like all other Plants, have their Origin from Seeds. But before these Seeds can vegetate there are required, certain Juices, proper to penetrate their Coats, to excite a Fermentation in them, and to nourish the minute Parts thereof. Hence arises that vast Diversity of Places, wherein different Sorts of this Plant

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are produced. Some will only grow on other particular Plants, whose Trunk or Roots have the Juices proper for them. Nay, there is one Sort which grows only on the Fillets and Bandages of the Patients in the Hospital at *Paris*. It is not therefore at all surprizing that Horse-dung should be a fit Soil for common Mushrooms, It is probable the Seeds of these are spread in numberless Places, well-nigh throughout the whole Earth. And the same may be said concerning the Seeds of many Plants, as well as the Eggs of many Insects: More especially of those which are so minute, that we can scarce discern them even with Glasses: Seeing the smaller they are, the more easily may the least Wind convey them hither and thither. So that in truth the Earth is full of an inconceivable Number both of Animals and Vegetables, perfectly formed in all their Parts, and designed as it were in Miniature; only waiting for certain favourable Circumstances to enable them to make their Appearance at large. How rich then must that Hand be, which hath sown them with so much Profusion!

It may not be improper before concluding this Head, to describe one Species of *Sea-plants*. *Coral* grows chiefly in Grottoes which open to the South, and whose Concave Arch is nearly parallel to the Surface of the Earth. It will not grow at all, but where the Sea is quiet as a Pond. It vegetates the contrary Way to all other Plants; its Root adhering to the Top of the Grotto and its Branches shooting downward. The Root takes the exact Form of the Solid it grows to, and covers it (as far as it goes) like a Plate: And this is a probable Proof, that its Substance was originally Fluid. Accordingly Corals sometimes line the Inside of a Shell, which they could not have entered but in a fluid Form. All its Organism, with Regard to Vegetation, seems to consist in its Rind, in the little Tubes whereof the Juice runs to the Extremities of the Branches. And this Juice petrifying both in the Cells, that encompass the coralline Substance, and in those at the Extremities of the Branches, whose Substance is not yet formed, by this Means enlarge the Plant to its full Dimensions, both in Height and Bulk.

It is vulgarly
believed,

believed, That Coral is soft while in the Water. But Experiment proves the contrary.

It is observable, that all *Sea-plants*, (except the *Alga*) are without Roots. Nor have they any longitudinal, capillary Sap-vessels, thro' which rooted Plants draw Nourishment to every Part. But the whole Substance of *Sea-plants* is composed of Vesicles, which receive their Nourishment immediately from the surrounding Water. Consequently they can have no Circulation of the Sap, having no Vessels to convey it from one End of the Plant to the other.

There is one *Sea-production*, if it may be so termed, that is not commonly understood. *Ambergris* is vulgarly supposed to be the Scum of the Sea. But it is not: Nor is it the Excrement of the Whale. It is in Reality a Kind of Gum, which issues out of the Root of a Tree. That Tree always shoots forth its Root toward the Sea; and when this Gum is discharged into it, it is so tough, that it is not easily broken from the Root. But when it is separated from it, either by its own Weight, or the tossing of the Sea, it floats upon the Water.

2. The Principle of *Corruption* in Plants and Animals, is probably the very same, which during a State of Circulation, is the Principle of Life: Namely, the Air, which is found in considerable Quantities, mixt with all Sorts of Fluids. This has two very different Motions; an Expansive one, arising from its natural Elasticity, by which it gives their Fluids an intestine Motion, and gradually extends the Parts that contain them: And a Progressive Motion. It does not appear, that this is essential to it. Rather it is occasioned by the Resistance of the solid Parts. This restraining its Expansion, obliges it to take the Course that is more free and open, which is thro' the Vessels of Plants and Animals.

When this Course is stopped, the expansive Motion remains, and still continues to act, 'till it has so fully overcome the including Bodies, as to bring itself to the same Degree of Expansion with the outward Air. But this it cannot do, without destroying the Texture and Continuity of those Solids, which we call *Corruption*.

This

This destructive Quality of the Air is promoted; either by weakening the Tone or Cohesion of the including Parts; as when Fruit is bruised, which corrupts in that Part much sooner than in the others: Or by increasing the expansive Force of the Air, by Heat or some other co-operating Circumstance.

And certainly there is no Corruption, or Putrefaction, without Air. Hence either vegetable or animal Bodies buried deep in the Earth or Water, remain for Ages entire, which when exposed to the Air, quickly moulder away. And hence such Vegetables as are most apt to putrefy, remain unchanged in Vacuo.

Yet various Experiments seem to shew, That Air must be impregnated by Water, before it can occasion Putrefaction, either in animal or vegetable Substances. For take a Pound of fresh Flesh, and keep it in a moderate Heat, and it will thoroughly putrify in a few Days. But if you first extract the Moisture, it will harden like a Stone. And it may then be kept for Ages, without any Putrefaction. Even Blood, if you deprive it of its watry Part, may be kept for fifty Years. But if you then dissolve it in Water, and place it in a gentle Warmth, it will putrify immediately.

The Process of Putrefaction may be learned from an easy Experiment. Take the green, juicy Parts of any fresh Vegetable, throw them together in a large Heap, in a warm Air, and lay a Weight upon them. The middle Part of the Heap will soon conceive a small degree of Heat. It will grow hotter and hotter, till it comes to a boiling Heat, and is perfectly putrefied.

In three Days from the first putting them together, the Heat will equal that of an human Body in Health. By the fifth Day, the Heat will be such as the Hand can hardly bear. By the seventh or eighth, all the Juices are generally ready to boil. Sometimes the Matter will even flame, (as does moist Hay) till it burns away. But commonly it acquires a cadaverous Taste and Smell, and turns into one soft, pulpy

Mafs, much resembling human Excrements in the Scent, and putrefied Flesh in the Taste.

If this be distilled, there will come from it. 1. An urinous Spirit, perfectly like that obtained from Animals, and separable by fresh Distillation into pure Water, and a large Quantity of white, dry, volatile Salt, not to be distinguished from Animal Salts. 2. An oily Salt, which shoots into Globes; 3. A thick, fetid Oil, both which are entirely like those of Animals. 4. The Remainder, being calcined in an open Fire, yields not the least Particle of fixt Salt: Just as if the Subject had been of the Animal, not the vegetable Kingdom. And this Process holds equally in all Kinds of Vegetables, tho' of ever so different Natures. Yea, in dry Vegetables, so they be moistened by Water, before they are thrown into Heaps.

By this Means the Difference between one Vegetable and another, is entirely taken away. By this Process, they are all reduced to one common Nature: So that Wormwood, for Example, and Sage, become one and the same Thing. Nay, by this Means the Difference between Vegetables and Animals is quite taken away: Putrefied Vegetables being no Way distinguishable from putrefied Flesh. Thus is there an easy and reciprocal Transition of Animal into Vegetable, and Vegetable into Animal.

3. So true it is, that Matter, as Matter, has no Concern in the Qualities of Bodies. All depend on the Arrangement of the Particles, whereof each Body consists. Hence the Water, though tasteless, feeds aromatic Mint, and the same Earth gives Nourishment to Bread and Poison.

As to this Arrangement, the first View of a Vegetable gives us an idea, of infinitely numerous and various Parts: And so complex, that many have been discouraged from prosecuting the Research. But upon Examination, the Parts which appear so numerous, are reduced to a very small Account. For a careful Maceration in soft Water will shew, that the Parts really distinct are only seven. These 1. An outer Bark, 2. an inner Rind, 3. a Blea, 4. a fleshy Substance, 5. a Pith.

5. a Pith. There is between the Flesh and the Blea, 6. A vascular Series, and 7. Cones of Vessels take their Course within the Flesh.

Whatever Part of the Plant we examine, we find these, be it a Fibre, the Root or the Stem. We never find more. And tracing these, we see the other Parts of the Plants are only the Productions of them. Thus the Root, its descending Fibre, and the ascending Stalk, we find are one, not three Substances. The same seven Parts are continued from one to the other, and what are supposed at its Summit, to be many new and strange Parts, are found to be no more than the Terminations of these seven. The external Parts are also seven. 1. The Cup, 2. The outer Petals, 3. The inner Petals, 4. The Nectaria, either distinct, or connected in one Ring, 5. The Filaments, 6. The Receptacle of Seeds, and 7. The Seed-vessels or Seeds. And these are only the Terminations of the seven constituent Substances of the Plant. The outer Bark terminates in the Cup, the inner Kind in the outer Petals; the Blea forms the inner Petals, the vascular Series ends in the Nectaria, and the Flesh in the Filaments: The Cones form the Receptacle, the Pith the Seed and their Capsules. These are universal in Plants, though their Course be less plain in some, and their Terminations less distinct in others.

Every Piece therefore cut from a Plant transversely contains all the Parts of the Plant, ready to grow in Length into a Stalk upwards, and into a Root downwards, and to separate at a due height from the Root, into the several Parts of the Flower.

Thus we see the Arrangement of the common Particles of Matter into a vegetable Body, altho' it be a Work worthy of his Hand who formed it, yet is not so complex a Thing as it appears. And this Arrangement being once made in one individual, the Species is created for ever. For Growth is the Consequence of the Arrangement, when it has Heat and Moisture.

4. Upon the whole: If we consider every Part of a Plant, we shall find none without its Use. The Root draws Nourishment from the Earth: The Fibres convey

convey the Sap : The *larger Vessels* contain the Specific Juice of the Plant : *Others* carry Air for such a Respiration as it needs. The outer and inner *Bark* in Trees, defend them from Heat and Cold and Drought, and convey that Sap which is required, for the annual Increase of the Tree. And in Truth every Tree may in some Sense be said to be an annual Plant. For both Leaf, Flower and Fruit proceed from the Coat that was superinduced over the Wood the last Year. And this never bears more, but together with the old Wood serves as a Block to sustain the succeeding annual Coat. The *Leaves* serve, before the Bud unfolds, to defend the Flower and Fruit, which is even then formed ; and afterward to preserve them and the Branches, from the Injuries of the Summer Sun. They serve also to hinder the too hasty Evaporation of the Moisture about the Root. But their chief Use is, to concoct the Sap, for the Nourishment of the whole Plant : Both that they receive from the Root, and that they take in from the Dew, the Rain and the moist Air. Add to this, that they are as Lungs, which supply the Plant with the necessary Quantity of Air, and as excretory Ducts, which throw off Superfluities by insensible Perspiration. And so necessary is their Service, that most Trees, if quite stript of their Leaves, will die. And if in Summer you strip a Vine-branch of its Leaves, the Grapes will never come to Maturity. Not that they are hurt by the Sun : Expose them to this as you please, so the Leaves remain, and they will ripen well.

5. Another Point worthy our Consideration is, The immense *Smallness* of the Seeds of some Plants. Some are so extremely minute, as not at all to be discovered by the naked Eye. Hence the Number of Seeds produced by some Plants, is beyond Imagination : A Plant of *Redmace*, for Instance, and many Sorts of Fern produce above a Million : A convincing Argument of the infinite Understanding of the Former of them.

And it is remarkable, that such *Mosses* as grow upon Walls, the Roofs of Houses and other high Places, have.

have Seeds so excessively small, that when shaken out of their Vessels they appear like Smoke, or Vapour. These therefore may either ascend of themselves, or by an easy Impulse of the Wind be raised to the Tops of Walls, Houses or Rocks. And we need not wonder how the Mosses got thither, or imagine they sprung up spontaneously.

6. Concerning Vegetables in general we may farther remark, 1. That because they are intended to be Food for numberless Species of Animals, therefore Nature has taken so extraordinary Care, and made so abundant Provision, for their Propagation and Increase. So that they are propagated and multiplied, not only by the Seed, but also by the Root: Producing Shoots or Off-sets in some; creeping Under-ground in others. Some likewise are propagated by Slips or Cuttings; and some by several of these Ways. Secondly; for the Security of such Species as are produced only by Seed, most Seeds are endued with a lasting Vitality: So that if by Reason of excessive Cold or Drought, or any other Accident, they happen not to spring up the first Year, they may continue their Fruitfulness, I do not say, six or seven only, but even twenty or thirty Years. Nay, after this Term, if the Hindrance be removed, they will spring, and bring forth Fruit. Hence it is, that Plants are sometimes lost for a considerable Time, in Places wherein they abounded before. And after some Years appear anew. They are lost, either because of the unfavourable Seasons, because the Land was fallowed; or because Plenty of Weeds, or other Plants, prevented their coming up. And as soon as these Impediments are removed, they spring up again. Thirdly, Many Vegetables are armed with Prickles or Thorns, to secure them from the browsing of Beasts; as also to defend others, which grow under their Shelter. Hereby likewise they are made particularly useful to Man, either for quick or dead Fences. Fourthly, Such Vegetables as are weak and not able to support themselves, have a wonderful Faculty, to use the Strength of their Neighbours, embracing and climbing up upon them, and using them

them as Crutches to their feeble Bodies. Some twist themselves about others like a Screw: Some lay fast hold upon them, by their curious *Claspers* or *Tendrils*, which herein are equivalent to Hands. Some strike in a Kind of Root: Others by the Emission of a natural Glue, firmly adhere to any Thing which has Strength sufficient to support them. Claspers are of a compound Nature, between a Root and a Branch. Sometimes they serve for Support only; as in the Claspers of Vines, whose Branches being long and slender, would otherwise sink with their own Weight: Sometimes, for a Supply of Nourishment also: As in the Trunk Roots of Ivy; which mounting very high, and being of a close and very compact Nature, the Sap would not be sufficiently supplied to the upper Sprouts, unless these assisted the Mother-root. Fifthly, The best of all Grain, and what affords the most wholesome and agreeable Nourishment is *Wheat*. And it is most patient of all Climates, bearing the Extremes both of Heat and Cold. It grows, and brings its Seed to Maturity, not only in the temperate Countries, but also in the Cold Regions of *Scotland*, *Denmark*, *Norway*, and *Muscovy*, on the one Hand, and on the other, in the sultry Heat of *Spain*, *Egypt*, *Barbary*, *Mauritania* and the *East-Indies*. Nor is it less observable, that nothing is more fruitful. One Bushel, when sown in a proper Soil, having been found to yield an hundred and fifty, and in some Instances, abundantly more.

7. It may be of Use to subjoin here, first a General View of *Vegetation*, secondly, some additional *Reflections* on the Vegetable Kingdom.

And first. As to *Vegetation* itself, We are sensible all our Reasonings about the wonderful Operations of Nature, are so full of Uncertainty, that as the wise Man truly observes, *hardly do we guess aright at the Things that are upon Earth, and with Labour do we find the Things that are before us*. This is abundantly verified in vegetable Nature. For tho' its Productions are so obvious to us, yet are we strangely in the Dark concerning them, because the Texture of their Vessels is so

fine

fine and intricate, that we can trace but few of them, tho' assisted with the best Microscopes. But altho' we can never hope to come to the Bottom and first Principles of Things, yet may we every where see plain Signatures of the Hand of a Divine Architect.

All Vegetables are composed of volatile Salt, Sulphur, Water and Earth, Principles which strongly attract each other: And a large Portion of Air, which strongly attracts when fixt, but strongly repells when in an elastic State. By the Combination, Action and Reaction of these few Principles, all the Operations in Vegetables are effected.

The Particles of Air distend each ductile Part, and invigorate their Sap, and meeting with the other mutually attracting Principles, they are by gentle Heat and Motion enabled to assimilate into the Nourishment of the respective Parts. Thus Nutrition is gradually advanced, by the nearer and nearer Union of these Principles, 'till they arrive at such a Degree of Consistency, as to form the several Parts of Vegetables. And at Length by the flying off of the watry Vehicle, they are compacted into hard Substances.

But when the watry Particles again soak into and disunite them, then is the Union of the Parts of Vegetables dissolved, and they are prepared by Putrefaction, to appear in some new Form, whereby the Nutritive Fund of Nature can never be exhausted.

All these Principles are in all the Parts of Vegetables. But there is more Oil in the more exalted Parts of them. Thus Seeds abound with Oil, and consequently with Sulphur and Air. And indeed as they contain the Rudiments of future Vegetables, it was necessary they should be stored with Principles, that would both preserve them from Putrefaction, and also be active in promoting Germination and Vegetation.

And as Oil is an excellent Preservative against Cold, so it abounds in the Sap of the more Northern Trees. And it is this by which the Ever-greens are enabled to keep their Leaves all the Winter.

Leaves

Leaves not only bring Nourishment from the lower Parts within the Attraction of the growing Fruit, (which like young Animals is furnished with proper Instruments to suck it thence) but also carry off the redundant watry Fluid, while they imbibe the Dew and Rain, which contain much Salt and Sulphur. For the Air is full of acid and sulphureous Particles; and the various Combinations of these, are doubtless very serviceable in promoting the Work of Vegetation. Indeed so fine a Fluid as the Air, is a more proper Medium, wherein to prepare and combine, the more exalted Principles of Vegetables, than the gross, watry Fluid of the Sap. And that there is Plenty of these Particles in the Leaves is evident, from the sulphureous Exudations often found on their Edges. To these refined aerial Particles, not only the most racy, generous Taste of Fruits, but likewise the most grateful Odours of Flowers, yea, and their beautiful Colours are probably owing.

In order to supply tender Shoots with Nourishment, Nature is careful to furnish, at small Distances, the young Shoots of all Sort of Trees, with many Leaves throughout their whole Length, which as so many jointly-acting Powers, draw Plenty of Sap to them.

The like Provision has Nature made, in the Corn, Grass, and Reed-kind: The leafy Spires, which draw Nourishment to each Joint, being provided long before the Stem shoots: The tender Stems would easily break, or dry up, so as to prevent their Growth had not these Scabbards been provided, which both support, and keep them in a supple and ductile State.

The Growth of a young Bud to a Shoot, consists in the gradual Dilatation and Extension of every Part, till it is stretched out to its full Length. And the capillary Tubes still retain their Hollowness, notwithstanding their being extended, as we see melted Glass Tubes remain hollow, tho' drawn out to the finest Thread.

The Pith of Trees is always full of Moisture, while the Shoot is growing, by the Expansion of which, the tender, ductile Shoot is distended in every Part. But when each Year's Shoot is fully grown, then
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the Pith gradually dries up. Meantime Nature carefully provides for the Growth of the succeeding Year, by preserving a tender, ductile Part in the Bud, replete with succulent Pith. Great Care is likewise taken to keep the Parts between the Bark and Wood always supple with slimy Moisture, from which ductile Matter the woody Fibres, Vesicles and Buds are formed.

The great Variety of different Substances in the same Vegetable proves, that there are peculiar Vessels for conveying different Sorts of Nutriment. In many Vegetables some of those Vessels are plainly seen, full of milky, yellow or red Nutriment.

Where a Secretion is designed to compose an hard Substance, viz. the Kernel or Seed of hard-stone Fruits, it does not immediately grow from the Stone, which would be the shortest Way to convey Nourishment to it. But the umbilical Vessel fetches a compass round the Concave of the Stone, and then enters the Kernel near its Cone. By this Artifice the Vessel being much prolonged, the Motion of the Sap is thereby retarded, and a viscid Nutriment conveyed to the Seed, which turns to hard Substance.

Let us trace the Vegetation of a Tree, from the Seed to its full Maturity. When the Seed is sown, in a few Days it imbibes so much Moisture, as to swell with very great Force, by which it is enabled both to strike its Roots down, and to force its Stem out of the Ground. As it grows up, the first, second, third and fourth Order of lateral Branches shoot out, each lower Order being longer than those immediately above them: Not only as shooting first, but because inserted nearer the Root, and so drawing greater Plenty of Sap. So that a Tree is a complicated Engine, which has as many different Powers, as it has Branches. And the whole of each yearly Growth of the Tree, is proportioned to the whole of the Nourishment they attract.

But Leaves also are so necessary to promote its Growth, that Nature provides small, thin Expansions, which may be called *primary Leaves*, to draw Nourishment to the Buds and young Shoot, before the Leaf is expanded.

expanded. These bring Nutriment to them in a Quantity sufficient for their small Demands: A greater Quantity of which is afterward provided, in Proportion to their Need, by the greater Expansion of the Leaves. A still more beautiful Apparatus we find, in the curious Expansions of Blossoms and Flowers, which both protect and convey Nourishment to the Embryo, Fruit and Seeds. But as soon as the Calix is formed into a small Fruit, containing a Minute, seminal Tree, the Blossom falls off, leaving it to imbibe Nourishment for itself, which is brought within the Reach of its Suction, by the adjoining Leaves.

8. I proceed to make some additional *Reflections* upon the vegetable Kingdom.

All Plants produce Seeds: But they are intirely unfit for Propagation, 'till they are impregnated. This is performed within the Flower, by the Dust of the *Antheræ* falling upon the moist *Stigmata*, where it bursts and sends forth a very subtle Matter, which is absorbed by the *Style*, and conveyed down to the Seed. As soon as this Operation is over, those Organs wither and fall. But one Flower does not always contain all these: Often the Male Organs are on one, the Female, on another. And that nothing may be wanting, the whole Apparatus of the *Antheræ* and *Stigmata* is in all Flowers contrived with wonderful Wisdom. In most, the *Stigmata* surround the Pistil, and are of the same Height. But where the Pistil is longer than the *Stigmata*, the Flowers recline, that the Dust may fall into the Stigma, and when impregnated, rise again, that the Seeds may not fall out. In other Flowers the Pistil is shorter, and there the Flowers preserve an erect Situation. Nay, when the flowering Season comes on, they become erect, tho' they were drooping before. Lastly, when the male Flowers are placed below the Female, the Leaves are very small and narrow, that they may not hinder the Dust from flying upward like Smoke: And when in the same Species one Plant is Male, and the other Female, there the Dust is carried in Abundance by the Wind from the Male to the Female. We cannot also without

Admiration

Admiration observe, that most Flowers expand themselves when the Sun shines, and close when either Rain, Clouds or Evening is coming on, lest the Genital Dust should be coagulated, or otherwise rendered useless. Yet when the Impregnation is over, they do not close, either upon Showers, or the approach of Evening.

For the scattering of Seed Nature has provided numberless Ways. Various Berries are given for Food to Animals; but while they eat the Pulp, they sow the Seed. Either they disperse them at the same Time; or if they swallow them, they are returned with Interest. The Mistletoe always grows on other Trees because the Thrush that eats the Seeds of them, cast them forth with his Dung. The Junipers also which fill our Woods, are sown in the same Manner. The Cross-bill that lives on Fir-cones, and the Haw-finch which feeds on Pine-cones, sow many of those Seeds, especially when they carry the Cone to a Stone or Stump, to strip off its Scales. Swine likewise and Moles by throwing up the Earth, prepare it for the Reception of Seeds.

The great Parent of all decreed that the whole Earth should be covered with Plants. In Order to this he adapted the Nature of each to the Climate where it grows. So that some can bear intense Heat, others intense Cold. Some love a moderate Warmth. Many delight in dry, others in moist Ground. The *Alpine* Plants love Mountains whose Tops are covered with eternal Snow. And they blow, and ripen their Seeds very early, lest the Winter should overtake and destroy them. Plants which will grow no where else, flourish in *Siberia*, and near *Hudson's Bay*. Grass can bear almost any Temperature of the Air: In which the good Providence of God appears: This being so necessary all over the Globe, for the Nourishment of Cattle.

Thus neither the scorching Sun nor the pinching Cold hinders any Country from having its Vegetables. Nor is there any Soil which does not bring forth some. Pond-weed and Water-lillies inhabit the Waters. Some Plants cover the Bottom of Rivers and Seas :

Others fill the Marshes. Some clothe the Plains: Others grow in the driest Woods, and in Places that scarce ever see the Sun. Nay, Stones and the Trunks of Trees are not void, but covered with Liver-wort.

The Wisdom of the Creator appears no where more, than in the Manner of the Growth of Trees. As their Roots descend deeper than those of other Plants, they do not rob them of Nourishment. And as their Stems shoot up so high, they are easily preserved from Cattle. Their Leaves falling in Autumn guard many Plants against the rigor of Winter: And in the Summer afford both them and us a Defence against the Heat of the Sun. They likewise imbibe the Water from the Earth, part of which transpiring thro' their Leaves, is insensibly dispersed, and helps to moisten the Plants that are round about. Lastly, the particular Structure of Trees contributes very much to the Propagation of Insects. Multitudes of these lay their Eggs upon their Leaves, where they find both Food and Safety.

Many Plants and Shrubs are armed with Thorns, to keep the Animals from destroying their Fruits. At the same Time these cover many other Plants, under their Branches, so that while the adjacent Grounds are robbed of all Plants, some may be preserved, to continue the Species.

The Mosses which adorn the most barren Places, preserve the smaller Plants when they begin to shoot from Cold and Drought. They also hinder the fermenting Earth from forcing the Roots of Plants upward in the Spring, as we see happen annually to Trunks of Trees. Hence few Mosses grow in Southern Climates, not being necessary there to these Ends.

Sea-Matweed will bear no Soil but pure Sand. Sand is often blown by violent Winds, so as to deluge as it were Meadows and Fields. But where this grows, it fixes the Sand, and gathers it into Hillocks. Thus other Lands are formed, the Ground increased, and the Sea repelled, by this wonderful Disposition of Nature.

How

How careful is Nature to preserve that useful Plant Grass? The more its Leaves are eaten, the more they increase. For the Author of Nature intended, that Vegetables which have slender Stalks and erect Leaves should be copious and thick set, and thus afford Food for so vast a Quantity of grazing Animals. But what increases our Wonder is, that altho' Grass is the principal Food of such Animals, yet they touch not the Flower and Seed-bearing Stems, that so the Seeds may ripen and be sown.

The Caterpillar of the Moth, which feeds upon Grass to the great Destruction thereof, seems to be formed in Order to keep a due Proportion between this and other Plants. For Grass, when left to grow freely, increases to that Degree as to exclude all other Plants, which would consequently be extirpated, unless the Insect sometimes prepared a Place for them. And hence it is, that more Species of Plants appear, when this Caterpillar has been, and laid waste the Pasture the preceeding Year, than at any other Time.

But all Plants, sooner or later, must submit to Death. They spring up, they grow, they flourish, they bear Fruit, and having finished their Course, return to the Dust again. Almost all the black Mould which covers the Earth is owing to dead Vegetables. Indeed after the Leaves and Stem are gone, the Roots of Plant remain; but these too at last rot and change into Mould. And the Earth thus prepared, restores to Plants what it has received from them. For when Seeds are committed to the Earth, they draw and accommodate to their own Nature the more subtle Parts of this Mould: So that the tallest Tree is in Reality nothing but Mould wonderfully compounded with Air and Water. And from these Plants, when they die, just the same Kind of Mould is formed as gave them Birth. By this Means Fertility remains continually uninterrupted: whereas the Earth could not make good its annual Consumption, were it not constantly recruited.

In many Cases, the *crustaceous Liverworts* are the first Foundation of Vegetation. Therefore however despised, they are of the utmost Consequence in the Economy of Nature.

Nature. When Rocks first emerge out of the Sea, they are so polished by the Force of the Waves, that hardly any Herb is able to fix its Habitation upon them. But the minute crustaceous Liverworts soon begin to cover these dry Rocks, tho' they have no Nourishment but the little Mould and imperceptible Particles, which the Rain and Air bring thither. These Liverworts dying turn into fine Earth, in which a larger Kind of Liverworts strike their Roots. These also die and turn to Mould: And then the various Kind of Mosses find Nourishment. Lastly, these dying yield such Plenty of Mould, that Herbs and Shrubs easily take Root and live upon it.

That Trees, when dry or cut down, may not remain useless to the World, and lie melancholly Spectacles, Nature hastens on their Destruction, in a singular Manner. First the Liverworts begin to strike Root in them, afterward the Moisture is drawn out of them, whence Putrefaction follows. Then the Mushroom-kind find a fit Place to grow on, and corrupt them still more. A particular Sort of Beetle next makes himself a Way between the Bark and the Wood. Then a Sort of Caterpillar and several other Sorts of Beetle bore numberless Holes thro' the Trunk. Lastly, the Woodpeckers come and while they are seeking for Insects, shatter the Tree already corrupted, and exceedingly hasten its Return to the Earth from whence it came. But how shall the Trunk of a Tree, which is immersed in Water, ever return to Earth? A particular Kind of Worm performs this Work, as sea-faring Men well know.

But why is so inconsiderable a Plant as Thistles, so armed and guarded by Nature? Because it is one of the most useful Plants that grows. Observe an Heap of Clay, on which for many Years no Plant has sprung up: Let but the Seeds of a Thistle fix there, and other Plants will quickly come thither, and soon cover the Ground. For the Thistles by their Leaves attract Moisture from the Air, and by their Roots send it into the Clay, and by that Means not only thrive themselves, but provide a Shelter for other Plants.

I shall add only one Observation more, concerning the Difference between *Natural* and *Artificial* Things.

Things. If we examine the finest Needle by the Microscope, the Point of it appears about a Quarter of an Inch broad, and in Figure neither round, nor flat, but irregular and unequal. And the Surface, however smooth and bright it may seem to the naked Eye, is then seen full of Raggedness, Holes and Scratches, like an Iron Bar from the Forge. But examine in the same Manner the Sting of a Bee, and it appears to have in every Part a Polish most amazingly beautiful, without the least Flaw or Inequality, and ends in a Point too fine to be discerned by any Glass whatever. And yet this is only the outward Sheath of far more exquisite Instruments.

A small Piece of the finest Lawn, from the Distance and Holes between its Threads, appear like a Lattice or Hurdle. And the Threads themselves seem coarser than the Yarn wherewith Ropes are made for Anchors. Fine *Brussels* Lace will look as if it were made of a thick, rough, uneven Hair Line, intwisted or clotted together in a very awkward and unartful Manner. But a Silk-worm's Webb on the nicest Examination appears perfectly smooth and shining, and as much finer than any Spinster in the World can make, as the smallest Twine is than the thickest Cable. A Pod of this Silk winds into nine hundred and sixty Yards. And as it is two Threads twisted together all the Length, so it really contains one thousand eight hundred and sixty; and yet weighs but two Grains and an Half. What an exquisite Fineness! And yet this is nothing to the Silk that issued from the Worm's Mouth when newly hatched.

The smallest Dot which can be made with a Pen, appears thro' a Glass a vast irregular Spot, rough, jagged and uneven about all its Edges. The finest Writing (such as the Lord's Prayer in the Compass of a Silver Penny) seems as shapeless and uncouth, as if wrote in Runic Characters. But the Specks of Moths, Beetles, Flies and other Insects, are most accurately circular. And all the Lines and Marks about them are drawn, to the utmost Possibility of Exactness.

Our finest miniature Paintings appear before a Microscope, as mere Dawbings, plaistered on with a Trowel. Our smoothest Polishings are shewn to be mere Roughness, full of Gaps and Flaws. Thus do the Works of

Art sink, upon an accurate Examination. On the Contrary, the nearer we examine the Works of Nature, even in the least and meanest of her Productions, the more we are convinced, nothing is to be found there, but Beauty and Perfection. View the numberless Species of Insects, what Exactness and Symmetry shall we find in all their Organs? What a Profusion of Colouring, azure Green, Vermillion; what Fringe and Embroidery on every Part! How high the Finishing, how inimitable the Polish we every where behold! Yea, view the Animalcula, invisible to the naked Eye, those breathing Atoms, so small, they are almost all Workmanship: In them too we discover the same Multiplicity of Parts, Diversity of Figures and Variety of Motions as in the largest Animals. How amazingly curious must the internal Structure of these Creatures be! How minute the Bones, Joints, Muscles and Tendons! How exquisitely delicate the Veins, Arteries, Nerves! What Multitudes of Vessels and Circulations must be contained in this narrow Compass! And yet all have sufficient Room for their several Offices, without interfering with each other.

The same Regularity and Beauty is found in Vegetables. Every Stalk, Bud, Flower and Seed, displays a Figure, a Proportion, an Harmony, beyond the Reach of Art. There is not a Weed whose every Leaf does not shew a Multiplicity of Pores and Vessels curiously disposed for the Conveyance of Juices, to support and nourish it, and which is not adorned with innumerable Graces to embellish it.

But some may ask, to what Purpose has Nature bestowed so much Expende on so insignificant Creatures? I answer, this very Thing proves they are not so insignificant, as we fondly suppose. This Beauty is given them either for their own Sake, that they themselves may be delighted with it. Or for ours, that we may observe in them the amazing Power and Goodness of the Creator. If the former, they are of Consequence in the Account of their Maker, and therefore deserve our Regard. If the latter, then it is certainly our Duty, to take Notice of, and admire them.

In short, the whole Universe is a Picture, in which are displayed the Perfections of the Deity. It shews not
only

only his Existence, but his Unity, his Power, his Wisdom, his Independence, his Goodness. His Unity appears in the Harmony we cannot but see in all the Parts of Nature; in that one simple End to which they are directed, and the Conformity of all the Means thereto. On every Side we discern either simple Elements or compound Bodies, which have all different Actions and Offices. What the Fire inflames, the Water quenches: What one Wind freezes, another thaws. But these and a thousand other Operations, so seemingly repugnant to each other, do nevertheless all concur in a wonderful Manner, to produce one Effect. And all are so necessary to the main Design, that were the Agency of any one destroyed, an Interruption of the Order and Harmony of the Creation must immediately ensue.

Suppose, for Instance, the Wind to be taken away, and all Society is in the utmost Disorder. Navigation is at a Stand, and all our Commerce with foreign Nations destroyed. On the other Hand the Vapours raised from the Sea, would remain suspended just where they rose. Consequently we should be deprived of that useful Covering the Clouds, which now screens us from the scorching Heat: Yea, and of the fruitful Rains. So our Land would be parched up, the Fruits of the Earth wither, ~~Animals die, and Hunger and Thirst~~ ^{Animals die, and Hunger and Thirst}, and all Nature languish and droop.

All the Parts of Nature therefore were constituted for the Assistance of each other, and all undeniably prove the *Unity* of their omniscient Creator.

His *Power* appears in the whole Frame of Creation, and his *Wisdom* in every Part of it. His *Independence* is pointed out in the inexhaustible Variety of Beasts, Birds, Fishes and Insects: And his *Goodness*, in taking Care of every one of these, *opening his Hand, and filling all Things living with Plenteousness.*

Every Thing is calculated by divine Wisdom, to make us wiser and better. And this is the Substance of true Philosophy. We cannot know much. In vain does our shallow Reason attempt to fathom the Mysteries of Nature, and to pry into the Secrets of the Almighty. *His Ways are past finding out.* The Eye of a little Worm

is a subject capable of exhausting all our boasted Speculations. But we may love much. And herein we may be assisted by contemplating the Wonders of his Creation. Indeed he seems to have laid the highest Claim to this Tribute of our Love, by the Care he has taken to manifest his Goodness in the most conspicuous Manner, while at the same Time he has concealed from us the most curious Particulars, with Regard to the Essences and Structure of his Works. And to this our Ignorance it is owing, that we fancy so many Things to be useless in the Creation. But a deep Sense of his Goodness will satisfy all our Doubts, and resolve all our Scruples.

The End of the First Volume.

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